NATURE

No. 4652 SATURDAY, DECEMBER 27, 1958 Vol. 182

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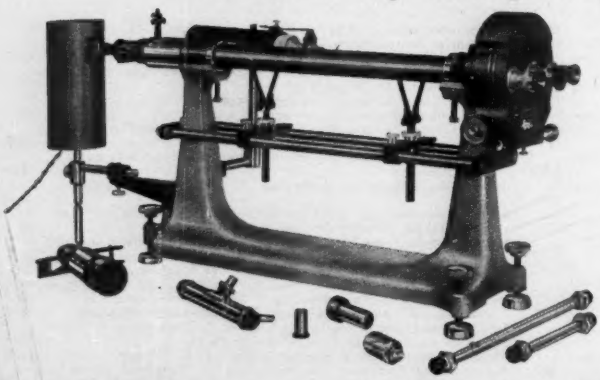

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ALLOCATION OF FUNDS FOR RESEARCH IN BRITAIN

ONE of the most important chapters in the recent report from the University Grants Committee on "University Development 1952–57" is that in which the Committee discusses the question of scientific research. After considering the balance between research and teaching, clear warning is given that, even if a reasonable proportion is maintained between them, balanced development of the work of the universities will only be ensured by unceasing vigilance that sponsored research and other outside support is not accepted on terms inconsistent with that development. The report then discusses in some detail the respective functions of the University Grants Committee and the research councils. This passage alone raised the whole question of the effective organization and management of the scientific effort of Britain within the pattern of values that characterizes our society and the peculiar requirements of science. It is clear that the University Grants Committee is deeply concerned with both the manner in which new lines of scientific work should be administered and the sources from which they should be financed.

The importance of this particular aspect of the subject has been emphasized recently by the criticisms of the Committee of Public Accounts of the Jodrell Bank radio telescope project and the situation which has led the University of Manchester to launch an appeal to raise the £150,000 still required to meet the costs. More generally, it was indicated by Prof. A. C. B. Lovell in the fourth of his Reith Lectures, on November 30, when he discussed formally the issues involved in the support of financial research by the State. Prof. Lovell made no direct reference to the Jodrell Bank situation, or to the proposal for a British programme of specialized space research which is understood to have been recommended by the Royal Society Conference on Space Research. It was rather the magnitude of the expenditure required to support such lines of research and the sacrifices inevitably demanded elsewhere with which he was concerned. Sacrifices may in fact well be demanded, if not in real standards of living, at least in some of the non-essentials that are too lightly taken for granted, without regard to the continuing scientific and technical effort through which alone they have been achieved.

Prof. Lovell did not stray into the field of politics or even of sociology; it was only obliquely that he indicated that a choice may have to be made between defence and security as at present conceived and the continued existence of mankind. Granted, however, that the transfer of effort and resources from the demands of defence to the constructive purposes of peace would release more than sufficient for the prospective needs of civil research and development, no statesman of any political party could contemplate such a step or propose the sacrifices that would be entailed or required by alternative measures without himself first very clearly apprehending what is involved from the point of view of science and technology, and then taking the most positive and energetic steps to prepare the electorate for whatever changes and sacrifices are required. As one first condition of any such attempt, both political parties must cease all attempts to make party capital out of the situation.

There is thus pre-supposed a very considerable campaign of education at high levels before we can hope to see any Government proposals allocating resources for scientific and technological development on the scale now desirable. Parsimony is not to be cured quickly, and there is always the over-riding problem of balance. Even a programme of £15 million a year over four years for space research is not to be approved lightly and without regard to possible repercussions on other fields of scientific and technological research; and once a programme has been approved, there is continuing need for public understanding and support. Sir Eric Ashby rightly remarked in his recent book "Technology and the Academics": "That a university should interpret itself to its patrons and explain its need for autonomy is . . . a necessary feature of its adaptation to the scientific revolution", and the comment is equally relevant to the independent research institutions and the research councils.

Prof. Lovell clearly recognizes this need for exposition and interpretation, and, although the administrative aspects were outside his survey, he just touched on the conditions of freedom and independence in which alone scientific research can flourish and which it should be a prime objective of administrative organization and policy to foster and preserve. Long-term dangers are inseparable from the support of fundamental scientific research by the State on a large scale, and the delicate and perilous situation which faces university administrators in Britain is without precedent. Failure to absorb these great new scientific projects into a framework where the traditional university freedom of inquiry can flourish would, he believes, be fraught with grave dangers to scholarship and scientific education.

All this is very clearly in the mind of the University Grants Committee, and in this perspective the actual balance of effort between teaching and research appears to be a secondary issue. In any event, the Committee rejects the view that the balance could be determined precisely, or even that the cost of research in universities can be estimated closely. It suggests that the cost of scientific research in universities in science, technology, medicine and agriculture was about £16 million in 1955–56 and probably £20 million in 1957–58, part of the difference being due to an increase in academic salaries. Of this amount, £2,307,000 in 1955–56 was received for research sponsored by bodies outside the universities,

£1,246,000 coming from the research councils and other Government departments.

In 1956–57 these figures rose to £2,683,000 and £1,377,000, respectively, and although they do not cover all the expenditure which could be apportioned to research if the whole of the recurrent expenditure of the universities were divided between the various activities carried out in them, the University Grants Committee appears to be justified in its view that government departments and agencies are not making excessive demands on universities in the matter of sponsored research. Research which is financed by the Council for Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council and the Nature Conservancy is generally free from these dangers, since it follows lines which are selected predominantly by the university research workers themselves; hence the Committee is disinclined to extend its own responsibilities for financing academic research.

Without some clarification of this point, however, the views of the University Grants Committee may not be generally shared. The re-organization now proceeding under the Council for Scientific and Industrial Research is being closely watched, and it is too early to feel any real assurance that such research will be supported more generously in the future, or even that the Council is the most appropriate means through which State grants should be made for fundamental research: the Jodrell Bank episode alone would suggest reserve on that point. Again, it cannot be suggested that support of the Nature Conservancy has been other than meagre, amounting almost to starvation where research is concerned.

Nevertheless, the University Grants Committee emphasizes a vital point in directing attention to the desirability of research workers in universities (or indeed in independent institutions anywhere) being able to obtain support from more than one source for lines of research which they wish to pursue. This is particularly true in respect of newly emerging lines of research, and though a Government source of finance cannot be expected to provide the same continuity or even support on the same scale at the start for the growing points as the independent foundation, there is sound reason for public support, in this way providing funds alternative to general university income. The problem is rather as to the means by which such support is most appropriately and effectively made available.

On this point, the University Grants Committee lays down very clearly its reasons for declining to be the source of earmarked funds for new lines of research. First, it insists that if university autonomy is to be a reality, it must continue to minimize its intervention in the allocation of funds within universities, which already receive 70 per cent of their income from the Committee. Secondly, it stresses the value of direct relations between a body supporting particular lines of research and the individual research worker and university department, as is possible with the research councils and the Royal Society. Again, the membership of the research councils and their committees, together with that of the Government Grant Boards of the Royal Society, includes the most experienced workers in the respective fields which they cover. Quite apart from the fact that the University Grants Committee, while exercising its present functions, could not give the same expert scrutiny and assessment to research projects without developing an unwieldy organization, the Committee makes the vital point that it is undesirable that such a single governmental colossus should bestride the whole university world. Finally, the universities have no monopoly of research, and it is necessary that any agency established to stimulate research in any field should be in a position to survey all the research in that field, decide whether any particular line of research is best pursued in a university or in some other establishment, and maintain due contact between university and other research.

This value of diversity of sources of finance is so great as to outweigh the possible danger of overlapping; nor is it likely that any serious gaps in the field of science will be left uncovered between the research councils and the Royal Society. Provided that reasonable funds are made available to them, the informal contacts already indicated should take care of both dangers, and where the independent foundations or industry do not also intervene to cover gaps, they are unlikely to escape the scrutiny of university departments; though it is admitted that the question of borderline fields and interlocking disciplines may require special attention. It may be recalled that Dr. L. V. Berkner, in the United States, has likewise stressed the importance of a diversity of sources of support for academic research, and the same point was made in the National Science Foundation's report on government–university relations, which outlined some principles recommended for the conduct of scientific research and development sponsored by the Federal Government in the United States.

The University Grants Committee suggests that the very success of a branch of research supported by a research council may create a problem of much greater practical importance when a topic previously receiving little recognition develops into a branch of learning of such importance as to require representation within the established departments of a university. Virology, chemical microbiology and biophysics started in this way; and it is clearly desirable that a line of original scientific work which has proved itself should be financed in the ordinary way from the general university income, and that the university should accept full responsibility for it instead of regarding it as an extraneous activity. The Committee is therefore making arrangements with the research councils to enable universities to assume financial responsibility for work that has hitherto been financed by a research council, when it can be regarded as established and ripe for transfer.

Thus flexibility, even a dynamic approach, are no less important than informality in whatever admin-

istrative arrangements are concerted for the support and co-ordination of research ; and the recent annual report for 1957–58 of the Advisory Council for Scientific Policy*, which has followed the report on university development, indicates that the Advisory Council is as aware of this as is the University Grants Committee, and that within its own framework it is seeking to foster the conditions in which science and learning best flourish. Indeed, whatever the level of State support for scientific and technological research, whether or not the nation derives the maximum return from that investment depends primarily on whether the right conditions are provided, including not merely equipment but also the supporting technicians and facilities such as libraries and information services in the broadest sense. With Britain's comparatively limited resources, it is the more important that the fullest possible use should be made of the scientific man-power and equipment available ; and it might well be prudent to give greater attention to this point at the moment rather than to open up new fields prematurely.

In its report for 1956–57, the Advisory Council on Scientific Policy indicated that it proposed to consider further whether the existing arrangements for financing pure research in the universities were as satisfactory as they should be ; and it was at the request of the Advisory Council that the University Grants Committee reviewed the nature and extent of its responsibility for financing university research and the part which the research councils and the Royal Society should also play. The reasons which led the University Grants Committee to conclude that the research councils and the Royal Society have an essential part to play, and that its own responsibilities should not be extended to cover it, are those on which its objections to being the source of earmarked funds for new lines of research are based. The Advisory Council on Scientific Policy sets forth the argument at length in its current report, and records that these considerations convinced the Council that the advantages of alternative sources of support for research outweigh any administrative disadvantages they entail. In this connexion it again stresses the value of the financial support given to pure research by the charitable foundations and by industry.

Quite apart from the addition thus made to the total expenditure on university resources, the existence of these alternative sources of support minimizes the danger that entirely novel ventures may go unsupported because of their very unorthodoxy. While the Advisory Council is primarily concerned to see that research workers with promising ideas are able to develop their researches, and that the best use is made of university staff and facilities, it discusses further the detection and filling of gaps in the research effort. This is one of two problems in the existing system that requires special attention : to the other—that of the transfer of responsibility for a line of research once well established—the University Grants Committee, the research councils and the Royal Society, as has been seen, are already giving continuing attention.

The Advisory Council points out that it is the established practice of the research councils to review both the work they themselves support and that being carried on by the universities and other bodies, with the view of identifying gaps in the field and concerting measures to anticipate future trends. From time to time committees of the Royal Society also review the whole range of research activities in science, with the view of detecting and directing attention to lines of research which do not appear to be receiving adequate support or are otherwise neglected. Nevertheless, there are fields of research which do not fall clearly or wholly within the sphere of interest of any one of the research councils, and in considering these the Advisory Council concludes that there is a danger that borderline subjects, and especially those calling for a team of experts from different disciplines, might fail to get the attention which, in the national interest, should be devoted to them. The Advisory Council mentions research into irrigation problems, ecological and physiographical studies and certain aspects of invertebrate physiology ; and there appears to be particular danger that this may arise with some of the work for which the Department of Scientific and Industrial Research has been responsible, if only as a result of the criticism to which the Department has recently been subjected.

The Advisory Council considers it important that a research council should not be restricted by too rigid a definition of its particular field, but should be allowed to expand its ambit to take account of widening interests as these arise. Clearly the research councils and the Royal Society have already the arrangements for informal consultation which, moreover, broadly meet the fundamental criterion that the identification and selection of programmes or projects for research should be in the hands of the scientists themselves. This should facilitate the identification of gaps ; but the Advisory Council does well to point out that it is vital that these arrangements should be kept under constant review and, if necessary, improved to guard against the danger of borderline subjects not receiving support.

While, therefore, such a system of multiple sources for financing research as exists in Britain provides reasonable safeguards both for academic autonomy and the freedom of the scientist and technologist to select and pursue his research objectives, it throws a considerable strain on administrative arrangements. Effective co-operation between the various grant-giving bodies is essential both to secure adequate finance and to prevent serious gaps developing in the research effort. Moreover, it does not appear that by itself it is sufficient to ensure that adequate support is forthcoming from Government sources.

That last is the only broad conclusion that can be drawn from a series of recent reports from, for example, the Committee of Public Accounts and the Select Committee on Estimates, particularly those relating to Treasury control, the Department of

* Annual Report of the Advisory Council on Scientific Policy, 1957–58. Cmnd. 597. Pp. 22. (London: H.M. Stationery Office, 1958.) 1s. 3d. net.

Scientific and Industrial Research and the construction of the radio telescope at Jodrell Bank. It is not simply that we have yet to devise an appropriate system of public accounting for the expenditure of public funds on large scientific and technological products. There is also the parallel problem of interpretation and exposition, so that Parliament and public understand clearly what is being done and what is needed, and are prepared to supply the requisite public funds.

In his remark, "The Civil Servant who is at the same time fellow of All Souls is the best guarantee one could have for the autonomy of British universities", Sir Eric Ashby gives a clue as to where the need is most likely to be met ultimately—in an adequate system of public education which will ensure that the ordinary citizen, whatever his or her occupation, has some understanding of what science is about, and that the administrator or Minister or member of Parliament is at least capable of appreciating the scientific issues in questions of public policy which are put to them. This lies, of course, outside the orbit of the Advisory Council, except in so far as its support of technological education and of the teaching of science contribute to that end. Nevertheless, the Advisory Council's eleventh report provides more encouraging evidence than recent reports that it is succeeding in getting greater attention given to varied ancillary factors which, in the aggregate, are of importance in ensuring Britain gets the maximum benefit from whatever resources in man-power and equipment are allocated for scientific and technological research.

CENTENARY OF GRAY'S ANATOMY

Gray's Anatomy : Descriptive and Applied

Edited by Prof. T. B. Johnston, Prof. D. V. Davies and Prof. F. Davies. Thirty-second (centenary) edition. Pp. xxiii + 1604 + 32 plates and 1,277 figures. (London and New York : Longmans, Green and Co., Ltd., 1958.) 126*s.* net.

THE publication of this centenary edition of "Gray's Anatomy" is a unique event, for no other medical text-book has been published under the same title for so long a period. During its life the book has more than doubled in cost but its size has changed from 750 to 1,604 pages, the illustrations from 363 to 1,309 in number; the medical curriculum has broadened, and there is an outcry against many features of pre-clinical teaching and of anatomy in particular. The outcry continues unabated but not unheeded; for twenty years, indeed longer, there has been a steady decline in the amount of detailed knowledge required of pre-clinical students, and increasing emphasis has been laid on principles of functional anatomy. However, structure and function should never be divorced, and generalizations become meaningless if the evidence on which they are based is not available. The incidence of diseases and the appearance of pathological lesions are changing with social conditions and the advent of antibiotics and chemotherapy, but sound diagnosis is still based on accurate observation and evaluation of the normal and of departures from it; and potent drugs can, and alas do, produce permanent disability if injected into main nerve trunks. Certain of the despised minutiæ provide a key to understanding normal and disordered function; the structure of the renal tubules and their blood supply are a case in point. The less information the student is required to remember, the greater is the need for a reliable reference book.

The editors have gone far towards meeting this requirement. The approach to the subject is systematic, but not unfunctional; the salient anatomical features are summarized and their functional significance is stressed in introductory chapters which engender a sense of proportion in the reader's mind. Those preceding the sections of arthrology, myology and neurology are noteworthy, although Fig. 801 in the latter is misleading. The basic features of histology are given with masterly brevity in 54 pages, and the section on embryology relieves the student from the necessity for buying a separate text-book. The minutiæ, as always, are relegated to small print. The few new terms introduced by the Nomina Anatomica, Paris, 1955, are listed and the editorial board "have taken full advantage of their freedom to translate the Latin forma into its English equivalent", and where the Paris term differs from the Birmingham revision the latter has been given in parentheses for the first occasion on which the structure has been mentioned. Loyalty to the decision to adopt this terminology has forced the use of the undesirable and illogical term 'syndesmology' for 'arthrology'. There are numerous references to original papers, many published within the past five years and several as recently as 1956; it was therefore surprising to find no mention of the work of Sholl on the cerebral cortex.

New illustrations include excellent photomicrographs of the cyclical changes in the endometrium and Weigert-Pal preparations of the brain stem, additional X-rays of the wrist and knee joints, and four electron micrographs which remind us of the widening field of cytology. The machine-finished paper, which has been used for the first time, enhances the beautifully clear type and illustrations, a few of which are marred by crudeness of colour and errors of over-printing. The over-stylized drawings of the thoracic skeleton and ligaments of the lumbar spine reappear, and some drawings of cross-sections of limbs suffer on comparison with previous editions by being left uncoloured. Few typographical errors have escaped the proof readers. The editorial board is to be congratulated most warmly on the care and skill expended in the extensive re-editing. This up-to-date book can be recommended unreservedly to medical students, who will find it of value throughout their careers.

Ruth E. M. Bowden

NOMINA REJICIENDA

International Code of Nomenclature of Bacteria and Viruses

Edited by the Editorial Board of the International Committee on Bacteriological Nomenclature. Pp. xxii + 186. (Ames, Iowa : Iowa State College Press, 1958.) 3.50 dollars.

ARE bacteria a class of plants, Schizomycetes, distinguished by the fact that they reproduce exclusively by simple fission, or are they not? The name has one virtue, one of the two allowed by

Mortimer Batten to the song of the kingfisher: nobody hears it. Because nobody, including the authors of this book, ever uses it; but the taxonomic system, of which the book is intended to be the instrument, hinges upon its validity.

Apart from the purely biological questions of the mutual and external relationships of bacteria, in which I have myself been interested, it has recently been proved that in the significant characteristic of cell-wall composition bacteria are *sui generis*. They are not plants, and they most decidedly do not confine themselves to simple fission.

There is no question that bacteria require a code of nomenclature, but there is every reason why this should be an effectively separate code, so that we may be spared such exercises as the consignment to limbo of well-known and useful names, *Listerella*, *Pfeifferella* or *Phytomonas*, on the ground that they have prior application to genera of protozoa. *Fritillaria* is both a plant and a pelagic ascidian, but this has not been the cause of any confusion. Greater confusion is likely to be caused by entitling as 'fungus' (*Malleomyces*) an organism that has more in common with the pseudomonads, or by substituting for a name invalidated by prior application to a genus of protozoon, one that has prior application to a green plant (*Listeria*).

The book is mainly concerned with rules for the nomenclature and valid publication of bacterial groupings. There is one rule of primary importance that is not stated, however: that any name, to be valid, must be accompanied by a description which enables the organism in question to be recognized. The firm application of such a rule would obviate the necessity for laboriously working out the priorities of all names published since 1753, since nine-tenths of them would be automatically invalidated.

Not that considerations of priority would appear to have over-riding force in these matters. *Bacterium coli* has many years priority over *Escherichia coli*, nor am I aware of any difficulties arising from its use, but not only does Opinion 15 forbid us to use it, it also informs us: "This Opinion is final unless revoked or modified by action of the International Committee on Bacterial Nomenclature". I wonder how much hope there is of finding that *Escherichia* has prior application in a genus of protozoon.

This part of the Code does not concern itself with the attachment of binomials to viruses, and perhaps that is not wholly a bad thing. K. A. Bisset

MARINE BIOLOGY IN SOUTH-EAST AFRICA

A Natural History of Inhaca Island, Mocambique
Edited by Dr. William Macnae and Dr. Margaret Kalk. Pp. v+163+11 plates. (Johannesburg: Witwatersrand University Press, 1958.) 42*s*.

WHEN the late Prof. C. J. van der Horst went to Johannesburg about twenty-five years ago he looked for a suitable place to conduct classes in marine biology and to undertake research. He found Inhaca Island, and his dream of a marine station there (the only one in the whole of South Africa) was realized in 1951, when the Portuguese Government established the laboratory with the collaboration of the University of the Witwatersrand.

Inhaca Island, which lies on the seaward side of the Bay of Lourenço Marques (Delagoa Bay) in latitude 26° S., is well placed, and is of particular interest from a biologist's point of view, "because it is close to the southernmost limit of the fauna and flora characteristic of tropical east African shores and at the same time it is the northernmost limit of the littoral fauna and flora of Natal and south-eastern Africa. The bulk of the fauna and of the algæ and intertidal marine flowering plants is of tropical origin".

This volume, which has been edited by Dr. W. Macnae and Dr. M. Kalk, is the work of many South African biologists who have visited Inhaca and who have contributed chapters on their special groups. In this way, during the short time the station has been in existence, a formidable list of species has been recorded and included here. The greater part of the book describes the marine life, but there are digressions on the land fauna and on the terrestrial vegetation. For botanists, there are chapters on the ecology of algæ and the sea grasses, with excellent check lists both of these and of the flowering plants.

The general ecology of the shore is well described by Dr. Kalk, and there is a great variety of intertidal habitats from the coral reef (an impoverished one) on the exposed seaward side of the Island, through numerous and often sheltered ecological niches, with substrata ranging from hard rock to sands of different compositions and to thick, water-logged mud in the mangrove swamps. These habitats are rich in species, and have, for example, yielded Prof. J. H. Day no fewer than 160 polychaetes. The major groups, molluscs (Dr. Macnae), crustaceans (Dr. Kalk), echinoderms (Prof. B. I. Balinski) and the fishes (Prof. J. L. B. Smith), are well represented, and the accounts are eminently suitable for the visiting student.

Prof. P. H. Boshoff describes the constitution and the development of the local coral reefs and it seems that species are few and limited to eurythermic ones. *Acropora*, for example, is represented by seventeen species—more than a hundred have been described—so that Inhaca may be a good place to ascertain whether even this reduced number possess distinct biological characteristics, or whether they are merely ecological variants of two or three species. It is perhaps relevant to mention here that the museums of the world contain extensive dry collections of such problem genera bearing a multiplicity of names, the significance of which, if any, remains to be elucidated through study of the living coral.

Keys are provided for the major groups and a habitat list indicates where the intertidal species can be found. Some groups of invertebrates are not included, notably Protozoa, Porifera and Polyzoa. In the brief account of coelenterates, *Muggiaea*, the name of a siphonophore, has been used for a scyphomedusa, and it should be noted that the chondrophores *Velella* and *Porpita* are pelagic hydroid colonies and are no longer considered to be siphonophores. Venomous invertebrates are not adequately noted for the student; there is no mention of the severe sting caused by the hydroid *Lytocarpus*, and the only cone shell specifically noted as causing a severe sting is *Conus ebraeus*, although two other species recorded from Inhaca, *Conus textile* and *C. geographus*, are both well known for their ability to produce fatal stings in human beings.

These minor defects should not be allowed to obscure what has been done; for the student and prospective research worker, this well-illustrated natural history *cum* fauna list is a remarkable achievement and provides a very good introduction to what Inhaca has to offer. W. J. Rees

HETEROCYCLIC CHEMISTRY

Current Trends in Heterocyclic Chemistry

Proceedings of a Symposium held at The John Curtin School of Medical Research, Australian National University, Canberra, 2nd–4th September, 1957, under the auspices of the Chemical Society. Edited by A. Albert, Dr. G. M. Badger and Dr. C. W. Shoppee. Pp. ix+170. (London: Butterworths Scientific Publications; New York: Academic Press Inc., 1958.) 30*s.*; 5.50 dollars.

Les Heterocycles Oxygenes

Colloques Internationaux du Centre National de la Recherche Scientifique, 64 (Lyon, 5-10 September 1955). Pp. 390. (Paris: Centre National de la Recherche Scientifique, 1957.) 2,500 francs.

The 1,2,3- and 1,2,4-Triazines, Tetrazines and Pentazines

By John G. Erickson, Paul F. Wiley and V. P. Wystrach. (The Chemistry of Heterocyclic Compounds: a Series of Monographs, Vol. 10.). Pp. xii+261. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 9.50 dollars.

"Current Trends in Heterocyclic Chemistry" records the papers which were read during a three-day symposium held in Canberra in 1957, and gives, in addition, a verbatim account of the discussions which followed each paper. The title, however, covers an immense field of current work, which clearly could not be adequately represented in twenty comparatively short papers: moreover, the authors have naturally tended to discuss work in which they were particularly interested. The result is that the volume is almost exclusively devoted to heterocyclic derivatives of nitrogen, with an occasional reference to those of oxygen and of sulphur. A more suitable title would have been "Some Current Trends", or alternatively "Current Australian Trends" (as Prof. A. Albert emphasizes in his introduction).

The papers are of considerable interest, and the fact that each is short and devoted to a strictly limited topic will make them particularly attractive to students. Furthermore, they are not limited to the pure organic chemistry of the heterocyclic systems: the physical side appears in papers such as "Physico-Chemical Studies on Solubilized Porphyrins" by J. N. Phillips, and "Spectrum and Bond-Type in Metalloporphyrins" by J. E. Falk and R. S. Nyholm, and the biochemical side in "Biotransformation Products of ^{14}C-Labelled Codeine and Morphine" by T. K. Adler.

The extent to which these studies of the nitrogen heterocyclic systems have been carried forms a striking testimony to the vigour and enthusiasm of the Australian chemists, more particularly Prof. Albert, the organizer and chairman of the symposium.

One might, however, question the advisability of including in volumes of this type complete reports of the discussions which follow the papers. During an informal discussion many quite minor points can often very usefully be raised, but some participants would hesitate to raise them if they knew that their queries would be recorded in full and published. Reports limited to the major points would avoid this factor.

"Les Heterocycles Oxygenes" contains thirty papers on heterocyclic derivatives of oxygen, and although the majority of the authors are French chemists, the other authors come from many lands and have thus made the colloquium truly international. Many of the papers differ from those usually found in reports of symposia in that they contain a fair amount of new experimental material, with yields, physical data, analyses, etc., of the compounds described: furthermore, each paper is followed by an apparently verbatim account of the discussion it provoked, and the complete collection therefore forms a volume of impressive size.

The papers on purely organic aspects deal mainly with the preparation of derivatives of furan and pyran, and the use of these derivatives in further synthetic work: the derivatives of pyran which receive most attention are naturally those of chroman and of flavone. Several papers deal with the isolation of cyclic oxygen derivatives from plant sources, and with the structure of these derivatives. The last paper discusses the biological action of certain heterocyclic oxygen compounds in the animal body.

An adequate yet brief review of so many topics clearly cannot be achieved, but the volume may be warmly recommended to organic chemists: it is excellently printed and produced apart from two faults, first, the table of contents appears at the end of the volume in place of a real index, and secondly, the fact that publication of the volume lags three years behind the colloquium itself.

The appearance of one more volume in the series on "The Chemistry of Heterocyclic Compounds" is warmly welcome, for the completion of the series will give organic chemists a detailed and authoritative account of almost every aspect of the subject. The six-membered cyclic triazines and tetrazines probably represent to many chemists one of the less-familiar sections of heterocyclic chemistry. Much of our knowledge is at present based on inadequate evidence, and the authors make the reservation that the "structures assigned to many of these compounds rest only upon their modes of formation and upon elemental analyses. We have accepted these structures without comment, except where equally likely or more plausible structures may be written".

Chemists are greatly indebted to the authors for this well-balanced and very thorough account of their subject. The greater part of the volume is naturally devoted to the 1 : 2 : 3-triazines, the 1 : 2 : 4-triazines and the 1 : 2 : 3 : 4-tetrazines, and the classification of the members of each of these groups is particularly clear. It is noteworthy that the final class—that of the pentazines—contains only one member, with considerable evidence that it is actually a tetrazole.

The contents of the volume cover material published up to 1950, with the inclusion of a few later references of particular interest.

The arrangement and the printing of the contents are very attractive, and considerably enhance the ease and pleasure with which the book can be read. It forms a valuable addition to the series.

F. G. Mann

The Story of Evolution

By Sir Julian Huxley. Pp. 72. (London: Rathbone Books, 1958.) 17*s.* 6*d.*

A SURVEY taken by the Audience Research Department of the B.B.C. showed that, despite developments in the teaching of biology in secondary schools, few members of the general public have much accurate knowledge of the theories of evolution and the facts upon which they are based. What better choice, therefore, than Sir Julian Huxley to tell how living things have evolved in a book meant for the layman and designed to combine education with entertainment. Evidence to support the theories of evolution is succeeded by an account of the mechanics of the process, the contemporary attitude to evolution and how it is likely to proceed. All this is explained in language which, though not difficult for the non-specialist to follow, lacks nothing of the precision contained in the author's standard and well-known work, "Evolution: The Modern Synthesis". The text forms a small part of the whole, however, and mainly serves to link the rich collection of attractively coloured diagrams, paintings and photographs; all the diagrams have been prepared by the Isotype Institute.

The photograph of T. H. Huxley on the cover-plate may serve to remind readers of the part played by Sir Julian's grandfather as Darwin's bull-dog three generations ago; this attractive volume will support the grandson's claim in the present generation.

T. H. HAWKINS

Lubrication Science and Technology

Vol. 1, No. 1. Edited by John Boyd. (Publication of the American Society of Lubrication Engineers. ASLE Transactions, Vol. 1, No. 1.) Pp. vii+231. (London and New York: Pergamon Press, 1958.) 105*s.* net.

DURING the past dozen years or more the American Society of Lubrication Engineers has been publishing in its monthly journal, *Lubrication Engineering*, a wide range of articles on lubrication problems. In addition, the Society has held annual conferences at which many papers have been presented, and has participated in conventions on lubrication organized by other scientific and technical bodies. Because of these activities and the increasing interest being shown in the field of lubrication, the Society has decided to publish on a semi-annual basis a volume of transactions to be known as "Lubrication Science and Technology". The first volume, under the editorship of John Boyd, has now appeared and contains nearly thirty articles.

The contents cover an extensive range of interests and appear to fall into three main groups. In the first group are articles dealing with the practical choice of metals and lubricants for specific applications, factors governing fatigue in bearings and gears, the phenomenological wear-behaviour of piston rings and the practical behaviour of solid lubricants. In the second group are papers on the more fundamental level dealing with the mechanism of boundary lubrication and the dependence of wear on specific interfacial interactions: in this group are two papers which attempt to approach metal-machining operations in terms of a rate-process mechanism. The third group deals with design problems and includes papers on finite journal bearings, hydrostatic bearings and the elasto-hydrodynamic behaviour of slider-bearings. There is also a short impressive paper on the design of thrust bearings which can operate up to loads of 2,000 tons or more. Two papers which reflect the atomic age deal with radiation damage in lubricants and lubrication by liquid metals.

It is clear from the selection of the papers included that a serious attempt has been made to balance technological and fundamental work. Nevertheless, the overall impression is that this volume reflects the Society's intention, clearly enunciated in the preface, namely, "to encourage the pursuit and dissemination of the basic technical information necessary for solving industry's problems" in the field of lubrication.

D. TABOR

Planetary Co-ordinates for the Years 1960–1980

Referred to the Equinox of 1950·0. Prepared by H.M. Nautical Almanac Office. Pp. xix+160. (London: H.M. Stationery Office, 1958.) 30*s.* net.

THIS volume is very much more than the ephemeral publication which its title might suggest. It is a continuation of two earlier publications which cover the years 1800–1940 and 1940–60 and extends in convenient form for a further twenty years the data which are needed in the computation of the positions of the smaller bodies in the solar system. The tabular matter is preceded by an introduction in which is given a detailed comparison of the methods for computing the perturbations of comets and minor planets, and at the end of the volume there is a collection of all the formulæ which are needed in eight different methods. These methods are scattered widely in the literature, and most of the text-books which discuss any of the methods do so from an academic point of view. Astronomers and students beginning the study of orbit computation have often felt the need for a more practical approach to the subject as a supplement to theoretical studies, and they cannot do better than master the contents of the descriptive pages of this volume. As a Government publication no names appear on the title page, but from the preface we learn that the authors were Dr. J. G. Porter, Dr. G. A. Wilkins and Mr. M. P. Candy, and we express to them our compliments on their excellent work.

R. H. GARSTANG

Aggression

By Dr. John Paul Scott. (The Scientist's Library—Biology and Medicine.) Pp. xi+149. (Chicago: University of Chicago Press; London: Cambridge University Press, 1958.) 28*s.* net.

THIS book claims to give "a concise account of scientific knowledge about aggressive behaviour in modern society—its causes, control and consequences". If this is what the reader expects, he will be rather disappointed. He will find two chapters which are reasonably documented. One discusses the physiology of aggression and surveys briefly some of the relevant work of Cannon, Bard, Ranson, Hess, Masserman, and Gellhorn. The other deals with hereditary influences, chiefly sex, size and breed differences in a number of species. The chapters concerned with psychological and social factors fall short of what might have been achieved on the basis of existing literature. In particular, the treatment of developmental, psychiatric, and anthropological aspects of aggression is far from adequate.

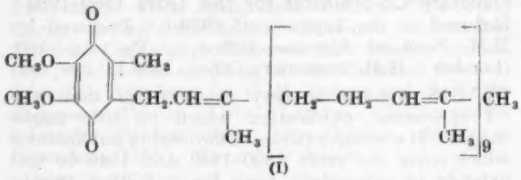
The author states that his primary aim is "to take the important results from current animal research and relate or contrast them with the facts of human behaviour". He has been more successful, however, in reporting the results of animal studies than in giving a convincing account of their bearing on the "facts of human behaviour".

J. COHEN

UBIQUINONE

By Prof. R. A. MORTON, F.R.S.
Department of Biochemistry, University of Liverpool

UBIQUINONE is a new substance of considerable biological interest which possesses the structure:



(I)

It would perhaps be more correct to say that this is the formula for the first of the ubiquinones, as there is already evidence of a plurality of compounds differing only in respect of the long side-chain.

Research on this compound has an interesting and perhaps instructive history. In 1950 G. N. Festenstein[1] obtained from the material lining the horse's gut a substance with an absorption peak at 272 mμ, E(1 per cent, 1 cm.) 195, an inflexion at 330 mμ, E(1 per cent, 1 cm.) 14 and a weak band at 400 mμ, E(1 per cent, 1 cm.) 8. This substance was labile to alkali but could be isolated either from tissue or from its unsaponifiable fraction. The work arose out of earlier investigations at Liverpool on intestinal tissue. It had been found: (*a*) that many species of fish contained large amounts of vitamin A in the intestinal epithelia and in the pyloric cæca; (*b*) that carotene could be converted to vitamin A in the absorptive part of the animal gut; and (*c*) that cholesterol could be dehydrogenated in the gut wall to form provitamin D. Festenstein's study revealed the presence of small amounts of intermediates between carotene and vitamin A as well as the existence of the new 272-mμ substance.

The yield from horse intestine was small, and J. C. Cain[2] began a systematic study of the minor constituents of unsaponifiable matter in liver in the hope of isolating enough of the 272 mμ substance to identify it. Large amounts of liver tissue (horse, ox, sheep) were worked up and the presence of the new substance in liver was established. Liver was not, however, the best raw material to have chosen, although it was natural for this mistake to be made in a laboratory much concerned with vitamin A. Horse liver and ox liver contain substantial amounts of carotenoids as well as of vitamin A, and these substances give rise to artefacts on prolonged processing. In the course of the chromatographic separations, cholest-3 : 5-dien-7-one accumulated in some fractions, and as the ultra-violet absorption spectra of this compound and the new substance are very similar near 270 mμ, it was not always possible to distinguish the two compounds.

Meanwhile, J. S. Lowe[3] and F. W. Heaton[4-6], in an attempt to throw light on the systemic mode of action of vitamin A, had been comparing the unsaponifiable matter, obtained from the livers of rats deficient in vitamin A, with corresponding fractions from the livers of control rats receiving small doses of vitamin A. Similar studies were made on other organs and tissues[7], and a standardized chromatographic procedure facilitated separations. The most interesting fractions were designated SA and SC, the former being the 272 mμ substance. The amounts of both substances SA and SC were greater in the livers of rats deficient in vitamin A than in those of the control animals, but there was little difference in the other organs. The changes in SA- and SC-content of rat liver did not appear in the livers of fowls or guinea pigs deficient in vitamin A. This finding reduced the likelihood that changes in substances SA and SC were direct consequences of the deficiency state. The absence of vitamin A, however, made it technically easier to isolate rich concentrates of substance SA.

Heaton and Lowe[4] obtained enough of substance SA from rat liver for preliminary characterization. A preparation showing E(1 per cent, 1 cm.) 272 mμ, 174 and $\lambda_{min.}$ 234 mμ (E(1 per cent, 1 cm.) 36·7) was examined in an infra-red spectrometer and was analysed for carbon and hydrogen. The molecular weight was determined by the Rast method, using both camphor and exaltone as solvents. The results agreed (430 and 433) and seemed trustworthy. It is now known that this was a good preparation and that the analyses were satisfactory, but the molecular weights were almost exactly half the true value. This failure of the Rast method led the whole investigation astray for a time.

The chromophoric properties of substance SA were matched very closely indeed by those of a type of ene-dione steroid structure occurring in cholest-8 : 9-en-7 : 11-dione[4,8]. The analyses and molecular weight made it necessary to explore the possibility that SA was a polycyclic substance of steroid nature. Attempted dehydrogenation (Wohl–Ziegler method and also palladized charcoal) gave no evidence of a polycyclic ring system. G. M. Wilson[9] prepared and examined a number of steroids and related substances containing the 8 : 9-en-7 : 11-dione grouping and showed that they were quite distinct from SA.

It now became clear that substance SA was a normal constituent of many animal tissues. N. F. Cunningham[10] had determined the SA-content of liver, and J. Vernon[10,11] the SA-content of kidney in many species. L. Mervyn[12,13] had found substance SA in human blood, heart and kidney, and also in a fœtus. Miss N. Fahmy[14] had found substance SA in the spleen and pancreas of various species, including man. In the course of a study of yeast unsaponifiable matter a substance, showing the SA spectrum ($\lambda_{max.}$ 272 mμ, E(1 per cent, 1 cm.) 167 in cyclohexane) and other properties, had been isolated (but not crystallized) by Heaton, Lowe and Morton[15]. F. W. Hemming and J. F. Pennock[16] had meanwhile observed that SA was mainly to be found in the mitochondrial fractions of liver and kidney tissue.

Wilson[9] prepared several batches of SA fractions from pig liver, and after rechromatography he was able for the first time to crystallize the compound. Pig liver was chosen because it is normally almost free from carotenoids and is not rich in vitamin A. When the crystalline material was analysed the

results agreed well with the earlier figures, but the Rast molecular weights were disconcertingly variable and higher. These values might have been due to partial dimerization, but the crucial importance of the molecular weight made it necessary to use other methods. The Barger method of isothermal distillation led to a molecular weight of 869 (chloroform as solvent) or 995 (acetone as solvent). Cryoscopic determinations using cyclohexane as solvent led to values from 890 to 1,000 (Hemming and Pennock).

SA was readily reduced by zinc and acetic acid to give a compound showing $\lambda_{max.}$ 291 mμ and E(1 per cent, 1 cm.) 52 (in cyclohexane). The infra-red absorption spectrum showed that the carbonyl bands of substance SA had been replaced by hydroxyl bands. The reduced form was readily re-oxidized to SA by shaking with alcoholic ferric chloride, but it formed a stable acetate. The oxidation-reduction potential of the system SA – reduced SA was found to be $E_0 = 0{\cdot}542$ volt (Wilson). Perbenzoic acid titration indicated 7·5 double bonds on a basis of a molecular weight of 642, or 10 double bonds on the basis of a molecular weight of 860. The low value of E(1 per cent, 1 cm.) for the absorption of reduced SA favoured a high molecular weight. W. M. F. Leat and J. F. Pennock studied the catalytic hydrogenation of SA and recorded an uptake of hydrogen consistent with 8 or 11 double bonds, depending on whether the molecular weight was taken to be 642 or 856. The fully hydrogenated compound was readily oxidized by ferric chloride and the absorption spectrum of SA reappeared almost quantitatively. The new product, however, took up only a small proportion of hydrogen. The whole operation was repeated on a larger scale, and it was found that this proportion was 1/11 that shown by substance SA itself. The molecular weight was thereby finally fixed at about 860 by an indirect method[17].

The behaviour of substance SA was thus consistent with a quinone–hydroquinone system as the chromophoric grouping, with a side-chain transparent to ultra-violet rays and containing 10 unconjugated double bonds. The largest fully characterized molecule of this type was until recently squalene, $C_{30}H_{50}$, with 6 unconjugated double bonds, although many years ago Channon[18] isolated a compound $C_{45}H_{76}$ from liver. Dimter[18] found this hydrocarbon, which he called hepene, in adult mammalian liver but not in fœtal liver, and confirmed the formula $C_{45}H_{76}$. Vitamin K_2 has been hitherto accepted as 2-methyl-3-farneso-farnesyl-1 : 4-naphthoquinone, but it has recently been found (Isler *et al.*[19]) that the main vitamin K-active substance of bacteria has a C_{35} side-chain instead of a C_{30} side-chain.

The possibility that substance SA was related to vitamin K was rejected: (*a*) because of the absence of the four narrow absorption bands in the region 240–280 mμ; (*b*) because the value of 0·542 volt for E_0 was too high; and (*c*) because dehydrogenation did not give a naphthalene spectrum. This meant that substance SA was probably a benzoquinone derivative, but only half the oxygen content could be accounted for in this way. Alkoxy determinations were made (7·07 per cent), and on the basis of a molecular weight of 860 two methoxyl groups became probable. Their presence would also contribute to the lowering of the oxidation-reduction potential of *p*-benzoquinone from 0·715 to 0·542 volt.

Towards the end of 1956, when the perbenzoic acid titration had indicated that substance SA contained a 'polyisoprenoid' system, the help of Dr. O. Isler, of Hoffmann–La Roche at Basle, was sought because of his great experience in the synthesis of such groupings. It was also felt that the scale of preparation of substance SA would have to be increased beyond the capacity of a university laboratory. Actually, J. Y. F. Paterson, Hemming and Pennock succeeded in obtaining 3 gm. of crystalline SA after considerable effort and expenditure on solvent, and Dr. U. Gloor, of Hoffmann–La Roche at Basle, obtained some 37 gm. by following on a fairly large-scale plant the procedures worked out at Liverpool. Dr. O. Schindler, of the University of Basle, undertook further structural investigations preparatory to projected synthetic work.

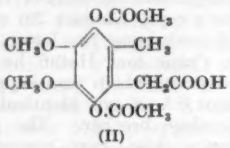
In 1957 (July 9) Dr. R. L. Lester, of the Institute of Enzyme Research at the University of Wisconsin, sent to Liverpool a copy of a note[20] on the isolation of a suspected quinone (*Q*275) from beef heart mitochondria. The covering letter stated "after this note was submitted we became aware of the interesting work of your group concerning the characterization of an unsaponifiable lipid material with $\lambda_{max.}$ 272 mμ (*Biochem. J.*, 59, 558; 1955). The ultra-violet and visible absorption of the material we have isolated corresponds very closely to your material. Since on reduction with potassium borohydride we find considerable absorption remaining in the 290 mμ region we thought that this might indicate a quinone–hydroquinone reaction. We would be happy to have your comments in this regard". In reply (July 12) a very full account of the results obtained at Liverpool was sent, including carbon and hydrogen analyses, determinations of molecular weight, infra-red and ultra-violet spectra, oxidation-reduction potential, perbenzoic acid titrations, etc. Mention was made that a steroid structure and many postulated naphthoquinone structures had been ruled out. Dr. Lester's reply (August 29) was most interesting. In acknowledging the letter of July 12 on behalf of Drs. Crane and Hatefi he wrote: "The generous information which was supplied leaves us in no doubt that SA, if not identical with Q275, is indeed a very close brother. The properties and analyses are quite close—even concerning the difficulty in obtaining a reliable molecular weight determination. I notice that several of the formulæ described in the letter contain an alkoxyl group—are your alkoxyl values similar to ours? Is there a possibility that an alkoxyl group is due to the presence of alcohol in the isolation? We plan an ozonolysis of the acetate derivative as a means of getting at the nucleus of the compound. Incidentally, Q275 shows no vitamin K activity in the animal assay". A summary of results was given showing very good agreement with those from Liverpool.

By this time it had clearly become necessary to summarize the Liverpool experience and to find a name for SA or Q275. Accordingly, Morton, Wilson, Lowe and Leat[17] suggested 'ubiquinone', and in their publication made reference to the work of Crane *et al.*[20].

The number of possible structures having been narrowed down, it was decided to search for model substances. The desiderata were a fully substituted quinone (since ubiquinone does not give the Craven test) containing two methoxyl groups. Aurantiogliocladin, 2 : 3-dimethoxy-5 : 6-dimethyl-*p*-benzoquinone had been isolated from a species of *Gliocladium* by Vischer[21] and synthesized unambiguously from *o*-4-xylenol by Baker, McOmie and Miles[22]. A

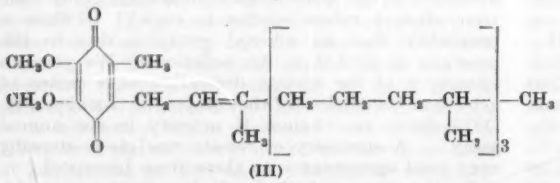
sample of aurantiogliocladin was kindly provided by Prof. W. Baker. This substance was found to show almost exactly the same ultra-violet absorption spectrum as perhydro-ubiquinone. The intensity of absorption E(1 per cent, 1 cm.) 272 mμ = 775 corresponds with a molecular extinction coefficient of 15,190. On the assumption of a molecular weight of 860 for ubiquinone, the E(1 per cent, 1 cm.) value would be 176, which is correct within the uncertainties of the experiment. The behaviour of aurantiogliocladin in ethanolic alkali was exactly similar to that of ubiquinone, although the sequence of chemical changes is not yet clear. Prof. Baker also provided a sample of 3-methoxy-2 : 5-toluquinone, and Dr. Isler and Prof. J. H. Birkinshaw provided samples of toluquinones with two methoxyl groups in the 3 : 4-, 4 : 6- and 3 : 6-positions. The spectra made it extremely probable that ubiquinone was an *o*-dimethoxy compound.

Dr. Gloor had also obtained methoxyl determinations (7·2 and 7·32 per cent), and Dr. Schindler had been able to convert the alkyl iodide obtained into the 3 : 5-dinitrobenzoate ester and had proved by melting point, mixed melting point and paper chromatography that the ester was indeed a methyl ester. This removed any doubt that the alkoxy determinations referred to methoxyl groups. Ubiquinol was obtained ($\lambda_{max.}$ 291 mμ, E(1 per cent, 1 cm.) 50) by reducing ubiquinone by means of hydrogen, using a partially poisoned palladium catalyst, and ubiquinol diacetate was crystallized; melting point, 37° C.; C, 79·5, 79·85 per cent; H, 9·93, 9·96 per cent; C.CH_3, 6·54 per cent. (Kuhn–Roth determinations at Liverpool gave similar low results, but this is not unusual for the method.) By ozonolysis of ubiquinone Dr. Schindler obtained acetone, lævulinic acid and a ring compound (II):



(II)

Dr. R. Rüegg had synthesized a compound, (III), which gave the same ring compound:



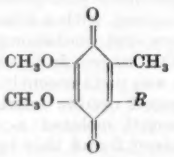
(III)

The dihydroderivative of (III) showed the same infrared absorption peaks as perhydroubiquinone, but the relative intensities were different.

Ubiquinone is in some sense a vitamin for the animal (inasmuch as the synthesis of the benzene ring cannot be effected), but until its biogenesis has been established its status in this respect remains uncertain. N. F. Cunningham[23] showed that guinea pigs deficient in vitamin C were normal in respect of substance SA, as were rats deficient in vitamin D. W. E. J. Phillips (unpublished work) has shown that animals deficient in vitamin K (made so by incorporating sulphadiazine into a diet lacking vitamin K) showed normal ubiquinone content. Mervyn's finding of ubiquinone in a fœtus probably rules out dependence on intestinal micro-organisms. Deprivation of vitamin E did not influence the level of ubiquinone. No diet at present in use for inducing deficiency of known fat-soluble vitamins has so far interfered with ubiquinone contents.

At the Fourth International Congress of Biochemistry held in Vienna in September 1958, Y. Hatefi read, on behalf of the Wisconsin group, a paper dealing with the coenzymic role of Q275 (ubiquinone), and Prof. E. C. Slater[24], of Amsterdam, discussed the biological role of ubiquinone in a survey of the role of tocopherol. In the discussion, M. Tishler, of the organic research group of Messrs. Merck, Sharp and Dohme, gave good evidence[30] for formula (II) for Q275.

The structure of ubiquinone was disclosed at the Sheffield meeting of the Biochemical Society (July 18) by Fahmy *et al.*[25] and quoted by Slater on the basis of the precirculated abstract. With a long chain of unconjugated double bonds it is obvious that neither *cis-trans* isomerism nor partial hydrogenation can be ruled out, any more than side-chains with less than fifty carbon atoms. There may, indeed, be many ubiquinones. Already much interest is being shown in the biochemistry of ubiquinone[26]. The Wisconsin group led by D. E. Green[27] indeed approached the subject through the study of mitochondrial enzyme systems, and because of this they have suggested[28] the designations mitoquinone and co-enzyme Q. In view of the use of Q to designate an enzyme of great importance in carbohydrate biochemistry, the latter suggestion has obvious disadvantages. Moreover, much remains to be discovered concerning the biochemical function of ubiquinone. Although the substance is found in mitochondria, the name 'mitoquinone' is perhaps less happy than ubiquinone with its reminder of widespread occurrence. The term ubiquinone may be used for all substances having the structure:



where R is an unsaturated side-chain. This can be described separately.

The ubiquinone of yeast has been proved by Gloor *et al.*[29] to differ from that of heart tissue, and at Vienna, Tishler also referred to a multiplicity of related compounds. The degree of purity needed for characterizing such compounds is not easily obtained on a small scale.

Detailed proof of the structure of ubiquinone will be given in a forthcoming joint publication by the Liverpool and Basle groups in *Helv. Chim. Acta*.

The work at Liverpool owes much to a grant from the Nuffield Foundation (1954–57) and to the award of scholarships to research students by the Agricultural Research Council and the Medical Research Council. Many colleagues have given valued assistance and advice.

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INCH-METRIC CONVERSIONS IN BRITISH STANDARDS

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WHEN legislation was first introduced in the United Kingdom to permit the use of the metric system of units where desired, provision was made to enable those who had to deal with metric measures to convert them into their equivalent values in the British system. A table of equivalent values was included in the Weights and Measures Act, 1878, but it was not until 1898 that a table of equivalents for weights and measures used in trade was prescribed in law (Statutory Rules and Orders No. 411). These equivalents include conversions from metric to British units and vice versa, but their primary purpose was to enable such metric measurements as were encountered in trade to be expressed in the usual, that is to say, the British, system of units. The use of these conversion factors has since extended, partly as the result of increased trade with countries using the metric system and partly as the result of certain industries in Britain using the metric system. To-day many conversions enter into the specifications found in British Standards. "Conversion Factors and Tables" (B.S. 350), which is now undergoing revision, gives a wide range of information regarding conversion factors in general. The concurrent use of both systems of units is recognized by the International Organization for Standardization (ISO), which makes due provision for conversions between British and metric units. The change to the metric system in India has also contributed to the need for publication of authentic conversion factors.

Of the conversion factors in use, those for the conversion of inch and metric sizes are of great importance in trade in countries using the metric system. Such conversions are needed, not only for describing equivalent nominal designations in the two systems but also for the purposes of functional interchangeability between articles made to specifications in either system of measurement. In many cases precise dimensional interchangeability is required. Such precise conversion of inch and metric sizes sometimes necessitates a close examination of the basis of the accuracy of the conversion factor used.

Basis of Conversion

Since the British yard and the metre are defined by reference to the material prototypes called respectively the imperial standard yard and the international prototype metre, the relation between these is a matter for experimental determination. One such determination had been made a few years before the issue of the Order in Council of 1898, and the result was included with the basic equivalents given in the Order. For the purposes of trade, rounded conversion factors were legalized, and the factor 1 inch equals 25·400 mm came into use. This round value was estimated to be correct to within one part in a million. It was afterwards applied to other conversions than those for measures of length occurring in trade, and was used, for example, in the determination of conversions for pressure and stress and other quantities, as required in science and industry.

In the first edition of "Conversion Factors and Tables" (B.S. 350), issued in 1930, the use of the round factor 1 inch equals 25·4 mm was recommended. So far as accuracy was concerned, this simple factor was amply sufficient for most purposes, and only in exceptional cases where fine measurements were involved was there any need to use a more precise conversion.

In two respects, however, it became necessary later to reconsider the appropriateness of using the factor. A further determination of the relationship between the yard and the metre (made in 1922 by the National Physical Laboratory on behalf of the Board of Trade, which has the custody of the imperial standard yard) showed that the round factor 1 inch equals 25·4 mm was then true to within two parts in a million. While confirmatory measurements made in 1932 indicated that any change in the relationship was

very small, a further determination in 1947 revealed a progressive shortening of the imperial standard yard.

In the meantime, metric measures were of sufficient importance in American industry to lead to the adoption of a simple factor for converting inch to metric sizes. In 1933, the American Standards Association approved the adoption of the round factor 1 inch equals 25·4 mm for industrial use in its standards. The adoption of the same conversion factor for industrial purposes by Britain and by the United States was of evident advantage to both countries. The factor was sufficiently simple to enable, for example, gear wheels having 127 teeth to be used in machine tools and measuring machines for the direct conversion of inch to metric measures.

Status of Round Factor

The factor 1 inch equals 25·4 mm does not purport to define the inch in either country. In Britain the inch is defined by reference to the imperial standard yard, as prescribed in the Weights and Measures Act, 1878. In the United States the inch is derived from the metre by means of the definitive relationship, 1 yard (US) equals (3600/3937) metre. The difference between the British and the United States inches amounts to four or five parts in a million, the former being the smaller. The round factor 1 inch equals 25·4 mm corresponds to an inch which lies approximately midway between these two inches and can, therefore, be regarded as representing either of them with an accuracy of two (or three parts at most) in a million.

While for most purposes this difference is not of serious consequence, difficulties have arisen in regard to some types of precision engineering products which are made to very fine tolerances. In such cases products found acceptable in the United States might be rejected in Britain, and vice versa. It is significant that greater interchangeability of precision products among the different countries using either system of units is called for by modern conditions of life, apart from the experiences of the Second World War. Moreover, an urge in this direction comes also from International Standards conferences and from the defence requirements of several countries.

Proposals to Re-define the Inch

The fact that the inch is not uniquely defined throughout the world presents an embarrassing problem from national and industrial points of view. The continued use of the imperial standard yard (the legal standard) as the fundamental standard of length in the British system, in view of the evidence of a progressive decrease in its value in terms of the international metre, accentuates the difficulties encountered in reference to fine measurements of length.

About twenty years ago, a proposal to redefine the inch as exactly equal to 25·4 mm, corresponding to 1 yard equals 0·9144 metre, was made in Commonwealth countries and in the United States. This proposal, with a similar one for the pound, was discussed by British and American metrologists during the Second World War and was put forward by the British Commonwealth Scientific Official Conference in 1946. It was also recommended by the Inter-Departmental Committee on Weights and Measures Legislation in 1951. Legislation to give effect to these proposals in Britain has not so far been enacted. In the United States a similar proposal had been made before the Second World War, but had met with opposition from certain engineers and surveyors, including the Coast and Geodetic Survey. Further efforts were made in the years following the Second World War, but the same opposition again prevented legislative action being taken. It is now proposed by the U.S. National Bureau of Standards that an 'international yard', defined as exactly equal to 0·9144 metre, should be established by negotiation with the major English-speaking nations and should be used generally for scientific and industrial purposes. This approach would not require legislation by Congress, and the Coast and Geodetic Survey could continue the use of its present units so long as it is considered desirable.

In Canada the change was effected in 1951 by legislation defining the yard as equal to 0·9144 metre exactly. In Australia, provision for a National Standards Commission, to establish standards for various units of measurement, was made in the Weights and Measures Act of 1948, but no formal pronouncement for the yard or inch has yet been made.

Effects of Proposals on British Standards

It is too early to foresee the outcome of these proposals in Britain and the United States. A general adoption of the proposals for unifying the inch would remove all doubt as to the precise meaning of an inch and would translate, from an approximate to a definitive basis, the factor 1 inch equals 25·4 mm which has hitherto been used so extensively in different countries, and in particular in British and American Standards. All inch and metric conversions of length in British Standards would then be on a true and exact basis.

The British Standards most concerned are "Precise Conversion of Inch and Metric Sizes on Engineering Drawings" (B.S. 2856), and "Conversion Factors and Tables" (B.S. 350). In these Standards, and particularly in the former, the use of the round factor 1 inch equals 25·4 mm for all purposes of conversion may not at present meet all the requirements of accuracy in exceptional cases of high precision, and reference may need to be made to the best conversion from the particular inch (British, United States or Canadian) concerned. This difficulty would be overcome if the conversion factor were definitive, instead of being approximate.

In B.S. 350, the status of the factor 1 inch equals 25·4 mm is of great importance because the unit of length enters into the conversion of many compound units, for example, mechanical units and heat units. In the revision of this standard which is now being made, the slight differences between the British and United States inches (and likewise the pounds avoirdupois) have been dealt with by assuming a common basis for the inch, namely, 1 inch equals 25·4 mm (and also for the pound, namely, 1 lb equals 0·453 592 37 kg exactly). This enables most of the conversion factors between British and metric units to be applicable also to the corresponding United States units, with the exception of those units, chiefly units of capacity, which are markedly different in the two countries. This treatment in B.S. 350 provides a very good compromise for industrial purposes, coupled with its additional applicability to most United States units.

BACTERIOPHAGE RESEARCH

SECOND ROYAUMONT COLLOQUIUM

IN the summer of 1952, André Lwoff, of the Institut Pasteur, organized an International Bacteriophage Colloquium at the Abbaye de Royaumont near Paris, the first reunion of European and American phage workers since the renaissance of the early 1940's of interest in bacterial virus. That meeting was held at a crucial time in phage research; for it had only just been discovered then that the tail of the phage is the organ of attachment, that the deoxyribonucleic acid of the phage is the carrier of its hereditary information, that genetic recombination of the phage can be understood in terms of population genetics, that the prophage of lysogenic bacteria is located on the bacterial chromosome, and that genetic recombination in bacteria is a unidirectional process involving donor and receiver cells. It was, therefore, fortunate that an international group happened to meet to appreciate these novel findings, which permitted old questions to be reformulated at a higher level of sophistication.

An unfortunate change has occurred since that Colloquium, when it was still the rule that all first-rate phage workers were always aware of everything important in their entire field. In the past six years, phage research has experienced such a remarkable development that there remain few, if any, persons who still retain complete mastery of every aspect of knowledge of bacterial viruses. Hence, it was appropriate that a Second International Phage Colloquium should be held at Royaumont during July 28–August 2, attended by sixty workers from Australia, Belgium, Denmark, France, Germany, Great Britain, Italy, Japan, Hungary, Switzerland and the United States. No papers were read (nor lantern slides projected) at this meeting, nor will there be any publication. Instead, each session was devoted to the discussion of a given topic under the leadership of a chairman, after an introductory talk on the subject by a *rapporteur*, according to the following programme:

Topic	Chairman	Rapporteur
Anatomy of the Phage Particle	E. Kellenberger (Switzerland)	S. Brenner (Great Britain)
Metabolism of Infected Bacteria	R. M. Herriott (United States)	E. Volkin (United States)
Synthesis of Phage Constituents	O. Maaløe (Denmark)	G. Streisinger (United States)
Kinetics of Recombination	A. H. Doermann (United States)	C. Bresch (Germany)
The Elementary Recombination Act	C. Levinthal (United States)	R. Edgar (United States)
Genetic Fine Structure	G. S. Stent (United States)	S. Benzer (United States)
Replication	F. H. C. Crick (Great Britain)	F. W. Stahl (United States)
Prophage and Chromosome, Transduction	E. S. Anderson (Great Britain)	J. Lederberg (United States)
Phage Conversion	B. A. D. Stocker (Great Britain)	N. Groman (United States)
Bacteriocines	G. Ivanovics (Hungary)	P. Frédéricq (Belgium)

As is evident from this programme, the discussions ranged over a wide field, and to attempt a synthesis of their outcome would be a formidable task indeed. Hence only a rather fragmentary selection of a few of the more important developments to emerge at these proceedings can be mentioned here.

Refined electron, optical and chemical studies reported by S. Brenner have shown that the tail of the bacteriophage consists of three proteinaceous parts: an outermost, cylindrical sheath, enclosing a hollow cylindrical core to which tail-fibres are attached at the distal end. The tail fibres seem to represent the real adsorption organs of the phage, since isolated tail fibres are fixed specifically to bacteria and contain almost all the serum-blocking power of the phage, in contrast to isolated sheaths and cores which possess neither of these properties. The phage, it seems, has a spring; for the sheath is a contractile organ which shortens and thickens when the tail of the phage makes contact with the host cell surface. The sheath, furthermore, is the site of action of adsorption co-factors and inhibitors, which affect the adsorbability of the phage by their influence on a reversible interaction between tail fibres and sheath. The following picture of the infection process may now be inferred from these facts: after phage and bacterium have collided, the phage tail-fibres flail about until they have made a stereospecific fit with the bacterial receptor sites and have anchored the particle firmly to the host surface. The sheath then contracts and pushes the core through cell wall and membrane, so that the viral deoxyribonucleic acid may pass from the head of the phage through the hole in the core into the interior of the bacterium.

Once in the interior of the infected bacterium, the viral deoxyribonucleic acid fulfils two tasks. It replicates itself several hundred-fold to produce the hereditary substance for the progeny particles and it induces the synthesis of viral protein. Parts of both of these processes can be seen directly in some striking electron micrographs of phage-infected bacteria, obtained by E. Kellenberger by means of novel staining and ultra-thin sectioning techniques developed in his laboratory. These pictures show how, in the course of intracellular phage growth, the bacterial 'nucleoids' disintegrate to give way to a pool of viral deoxyribonucleic acid, and how this pool at later stages (but prior to its encapsulation into morphologically intact, infective virus particles) crystallizes into hexagonal, pre-phage structures, which break up into free deoxyribonucleic acid and protein 'doughnuts' if the cell is lysed prematurely. The phage precursor deoxyribonucleic acid thus exists in at least two different states before its maturation, a fact which must be reckoned with if biochemical and genetic 'pool' estimations are to be correlated with one another. A revolutionary advance in the study of the role of viral deoxyribonucleic acid in viral protein synthesis was reported by G. Brown, who appears to have succeeded in inducing *in vitro* the formation of small but significant amounts of phage tail antigens by addition of purified phage deoxyribonucleic acid to preparations of disrupted bacterial cells. Brown has already carried out extensive control experiments to establish the reality of the effects produced in this system, which, if confirmed and developed further, bids fair to become a biochemical philosopher's stone. In the discussion of the replication of deoxyribonucleic acid, F. W. Stahl summarized his and M. Meselson's experiment, in which the density of the deoxyribonucleic acid of bacterial cultures initially labelled with nitrogen-15 was examined after various periods of

growth in non-labelled medium (containing only nitrogen-14). Meselson and Stahl have shown by means of this procedure that the replication of bacterial deoxyribonucleic acid follows a semi-conservative course. That is to say, exactly as envisaged by J. D. Watson and F. H. C. Crick, the two complementary polynucleotide strands of the deoxyribonucleic acid macromolecule appear to separate from each other for the replication act and join up with single, *de novo* polynucleotide chains to form two replica molecules, each containing one old and one new strand. The capital importance of this convincing experimental confirmation of the Watson–Crick proposal is obvious. It is hoped that one may know soon whether these results can also be extended to the replication of the phage deoxyribonucleic acid.

The work of many phage geneticists in recent years has indicated that genetic recombination is a process which must be intimately associated with the replication of the hereditary material, namely, deoxyribonucleic acid. It is therefore of great interest that C. Bresch presented a new analysis of the population dynamics of genetic recombination in phage, elaborated independently by himself and by F. W. Stahl and C. Steinberg. This treatment represents a generalization of the Visconti–Delbrück theory, not only in that the nature of the elementary recombination act is not presupposed but also in that the pairwise mating-event of the earlier theory is replaced by a 'co-operation' in which the number of participating particles may be greater than two. A generalization of this sort had become necessary for two reasons: first, studies by Bresch and others have revealed a number of facts which do not agree with the Visconti–Delbrück assumption that genetic exchange in phage occurs by breakage and reunion of homologous parts of mated parental structures. Secondly, Bresch has shown by means of a triparental cross that more than two particles 'co-operate' in genetic exchange, so that mating is *not* pairwise. The implications of the demise of pairwise mating for the understanding of the molecular basis of genetic recombination are not yet clear.

In connexion with this same problem, R. Edgar and A. H. Doermann discussed new experiments pertaining to heterozygotes, those unstable phage genotypes which harbour alleles from both parents of a mixed infection and which C. Levinthal first proposed as the transient zygotes formed at every elementary recombination event. Edgar concludes from crosses of several closely linked genetic loci that heterozygotes are indeed formed at the moment of genetic exchange. Furthermore, negative interference (that is to say, multiple exchange between three or more closely linked markers at a frequency greater than that expected from linkage data of two factor crosses) occurs at the time of the segregation of the heterozygote. In order to gain further insight into the genetic structure of the heterozygote, Doermann made crosses involving three closely linked markers and compared the frequency of progeny heterozygotic only for either one of the outside loci with the frequency of progeny heterozygotic only for the inside locus. Contrary to the 'overlap' model of heterozygote structure, now favoured by many phage geneticists, which predicts that phages heterozygotic for only the inside locus should be much less frequent than those heterozygotic for either one of the outside loci, Doermann found that all three types appear in roughly equal yield. Although it is now evident that both negative interference and heterozygosis must hold one of the keys to the understanding of the nature of the elementary recombination act, it is difficult to assess how soon a full comprehension of these phenomena may be at hand.

S. Benzer reported his work on mutation in a single genetic region, or 'cistron', of the bacteriophage. By mapping hundreds of independent mutants produced either spontaneously or under the influence of certain mutagens, he has constructed a mutational spectrum and thus obtained an image of the relative mutability of individual loci within a single gene. The spectrum of spontaneous mutations shows a few 'hot' spots at which mutants recur with high probability and a number of other sites mutating with lower probability. The spectra of mutation induced by 5-bromouracil, 2-amino-purine, or proflavine, all of which raise the overall rate of mutation in the cistron by two orders of magnitude, are very distinctive, in that each of the three mutagens creates its own set of 'hot' spots and mutable sites, totally unlike the set of mutable loci identified either among spontaneous mutants or among mutants induced by the other two mutagens. Bromouracil, amino-purine and proflavine, therefore, are specific mutagens, in the sense that each raises the probability of mutation only at definite genetic loci, rather than causing a generalized mutability of the entire genome. Since concrete notions concerning the mode of action of each of these mutagens can already be formulated in terms of the Watson–Crick structure of deoxyribonucleic acid, mutational spectra promise to bridge the gap between chemistry and genetics.

The past decade saw an ever-growing confluence of phage and bacterial genetics, particularly as non-infective prophage turned out to be an integral part of the bacterial genome in lysogeny, and infective phage a carrier of bacterial heredity in transduction. Recent studies on bacterial recombination, lysogeny and bacteriocines, presented at the Colloquium by J. Lederberg, by R. Frédéricq and by F. Jacob, have revealed, however, that the bacterial fertility factor *F*, the prophage and the colicinogenic factor have certain features in common which set them apart from other, or 'regular' bacterial genes. On the basis of these special properties, F. Jacob and E.-L. Wollman have created a new concept, the 'episome', defined as an exogenous hereditary determinant integrated into the bacterial genome by addition to the chromosome instead of replacement of allelic bacterial loci. Besides its integrated chromosomal state, the episome can also exist in an autonomous state, in which it is replicated independently of the rest of the bacterial genome. The episome promises to bring new order into the dialectics of virus-host genetics.

The second International Phage Colloquium can be considered to have been a great success; not only the participants but also phage workers in general must be grateful to its organizers, A. Lwoff and F. Jacob, and to the Rockefeller Foundation which provided financial support. The week of intimate and informal living within the historic Cistercian monastery founded by St. Louis in the thirteenth century once more promoted understanding, collaboration and personal friendship of a truly international nature. There seems little doubt that this Colloquium, like its predecessor, will have a profound effect on the development of bacteriophage research in coming years.

Gunther S. Stent

OBITUARIES

Mr. Cecil Warburton

Mr. Cecil Warburton died at his home in Grantchester, Cambridge, on October 7 at the age of one hundred and four years and eight months. Although he had lost much of his former physical vigour during the past year or two, he retained to the last his remarkable mental clarity, sense of humour and interest in people and current affairs. Warburton's work as an entomologist and arachnologist was known and respected by several generations of zoologists. His modesty and the charm of his simple and generous personality tended to cloak from those not familiar with his work the solid and enduring value of his scientific achievements.

Cecil Warburton was born on February 6, 1854, at Salford. He was educated at Old Trafford School, Manchester, where he later became second master. He attended classes at Owens College, Manchester, and took a University of London external B.A. degree. He went to Christ's College, Cambridge, in 1886, read for the Natural Sciences Tripos, graduated B.A. in 1889, and took his M.A. degree in 1892.

An early interest in spiders directed his zoological studies towards other Arachnida, and mites and ticks later became his main field of study. His knowledge of general zoology was wide, and he was appointed zoologist to the Royal Agricultural Society in 1893, and from that year until 1940 he wrote an annual report for the Society, dealing largely with economic entomology. At first these reports were addressed from the Department of Zoology, Cambridge, but from 1910 until 1940 they came from the School of Agriculture, where he lectured until his retirement in 1932, thus continuing an association with the teaching of agriculture in the University which had begun as early as 1899–1900 when his name appeared in the list of lecturers for the Board of Agricultural Studies. In 1909 Warburton was the author of Chapters 12–18 of Vol. 4 of the "Cambridge Natural History", which dealt with the Arachnida Embolobranchiata (scorpions, spiders, mites and ticks). This was an important and valuable work, and it provided the background to the fruitful association with G. H. F. Nuttall, then Quick professor at Cambridge, beginning in the Quick Laboratory in 1908, continuing in the Molteno Institute from 1921, and lasting until the death of Nuttall in 1937. It was during this period that his main original contributions were published, dealing with mites and ticks and culminating in the publication, by the Cambridge University Press, of "Ticks; a Monograph of the Ixodoidea", by G. H. F. Nuttall, Cecil Warburton, W. F. Cooper and L. E. Robinson. The first volume was written jointly by G. H. F. Nuttall and Cecil Warburton and comprised: Part 1, "The Argasidae" (1908); Part 2, "Ixodidae" (1911); and Part 3, "The Genus Hæmophysalis" (1915).

These studies were of great value to all workers in the rapidly developing subject of ticks as vectors of diseases of man and domestic animals, and they still remain standard works on ticks. Their preparation and publication resulted in a voluminous correspondence and the submission of collections of ticks for identification from all parts of the world. Replying to innumerable correspondents and identifying and reporting upon specimens occupied much of the time and energy of both Nuttall and Warburton for many years. Warburton continued identifying and reporting upon specimens of ticks until 1936, when he was eighty-two years of age; and there can be few, if any, collections of ticks in any country in the world which are not enriched by numerous specimens bearing on the label the words "identified by C. Warburton".

He had been appointed University demonstrator in medical entomology by the Quick professor in 1911, and he retained this post when the Quick Laboratory moved to the Molteno Institute in 1921. Thereafter, until he retired in 1932, his activities were mainly centred on the Institute, and he lectured on parasitic insects and arachnids, and demonstrated to students taking the courses for the diplomas in public health and tropical medicine and hygiene. He retained a keen interest in the Molteno Institute and those who worked in it to the end, and was an occasional visitor until after his hundredth birthday. Not only did he delight in meeting his old friends there, but also he was always pleased to meet new and younger workers, and all were warmly invited to visit him at his home in Grantchester and play croquet, a game at which he excelled until his sight failed in the last couple of years. He never married. All who knew him will feel they have lost a friend who was warm-hearted, generous and of high integrity both in his private and his scientific life.

P. Tate

Prof. Horace B. Dunnicliff

The news of the death on October 8 of Prof. H. B. Dunnicliff was received with great regret in India. Dunnicliff had been intimately associated with the growth of chemical education of the country for the past fifty years. He came out in 1908 as professor of chemistry of the M.A.O. College, Aligarh, where he taught chemistry until the First World War. In 1914, his services were placed at the disposal of the Khalsa College, Amritsar. In 1917, he was on deputation to the Munitions Board and was transferred to the Cordite Factory, Aravankadu. There he stayed until 1921 and did some very useful work. He was appointed professor of chemistry, Government College, Lahore, in 1922. On the reorganization of teaching of the Panjab University he was appointed University professor of inorganic chemistry. Here, a good school of chemistry was soon founded with the help of the late Santiswarup Bhatnagar. Bhatnagar was in charge of the teaching of physical chemistry and Dunnicliff looked after inorganic chemistry.

I was in charge of the organic chemistry section when Dunnicliff joined the Panjab University. The success of the Lahore School of Chemistry was largely due to the untiring efforts of Dunnicliff to keep the ship on an even keel in the stormy communal waters of the Panjab. He had a keen sense of justice and fair play, which kept the University teaching departments free from communal politics. He was seconded to the Government of India in 1928 with the view of organizing the Central Customs Analytical Laboratories. On his return to Lahore in 1929, his Laboratory acted as the appellate laboratory for all

matters relating to analyses performed by the various customs laboratories of the Indian ports. He was allowed to hold the post of special chemical adviser to the Finance Department of the Government of India in addition to his duties as a professor in the Government College and the University. This was a great strain, but he never grudged the extra burden placed on him. The work in connexion with the Customs Laboratory was not light. I deputized for him for two periods when he was on leave and I can affirm that this work was quite a full-time job. Ultimately his suggestion to have a Central Customs Laboratory at Delhi was adopted, and he finally migrated from Lahore in 1939 as the head of this new Laboratory.

During his tenure as professor in the University of the Panjab, Dunnicliff published a large volume of work in collaboration with his students, which earned for the Panjab University a reputation as an active centre of research work. Many of his pupils now occupy important positions both in India and Pakistan. They are all grateful for the helping hand he lent whenever they met difficulties. His migration to Delhi helped in putting the Central Revenues Chemical Service on a firm footing. During the Second World War I was again associated with him in war work. Owing to the large demand for morphine and codeine, the production at the Ghazipur Opium Factory had to be re-organized. He also designed the present morphine extraction plant at Ghazipur. He had a flair for designing plant and equipment. On his retirement from the Central Board of Revenues Laboratories, he joined the Department of Transport, New Delhi, where he had to design portable producer gas plants for use in lorries and motor-cars in order to minimize the use of petrol.

Dunnicliff presided over the Chemistry Section of the Indian Science Congress in 1934. He was on the Indian Committee of the Royal Institute of Chemistry, and he and the late Prof. Gilbert Fowler did much for the Institute in India.

Dunnicliff was a good singer, and many a pleasant evening was spent by his friends at his home; he was also a proficient amateur actor, and during the summer season he produced many plays at Simla.

Dunnicliff will always be remembered in India as a good Englishman who gave it more than he received from it. Those who knew him recognized him as a giver and not a taker. He lived in India at a critical period of her history. His contribution to the growth of science in India was by no means negligible.

He leaves behind a devoted wife, to whom our sympathy is offered. J. N. Ray

Dr. S. L. Smith, C.B.E.

By the death of Dr. S. L. Smith on October 27, engineering and in particular shipbuilding research in Britain have lost a prominent figure. Those who had the privilege of working with him will remember him as the most kindly and approachable of colleagues.

Stanley Livingston Smith was born in 1889 and received his technical education at the City and Guilds Engineering College, South Kensington, where he graduated as B.Sc. (London) and Associate of the City and Guilds Institute in 1909. A period of practical training at the Thames Ironworks, Shipbuilding and Engineering Co., Ltd., was followed by an engineering inspectorship with the Crown Agents for the Colonies. After a varied career during the First World War, including secret work for the Royal Society war committee and service as an engineering officer in the marine training section of the R.A.F., he returned to the City and Guilds College under Prof. W. E. Dalby. Awarded the degrees of M.Sc. in 1921 and D.Sc.(Eng.) in 1923 for his work on elastic hysteresis in steels, he was appointed assistant professor in 1926 and reader in mechanical engineering five years later. He represented the Imperial College of Science and Technology on the Surrey County Council and was appointed chief engineering inspector of technical institutions.

Just before the outbreak of war in 1939, he was appointed superintendent of the Engineering Department of the National Physical Laboratory. During the War he was responsible for the very varied warwork of that Department; to mention only three items, he was particularly concerned with the development of apparatus for rendering unexploded bombs harmless, gun design (he was a member of the Gun Design Committee), and (with the late Dr. G. A. Hankins) the building for external ballistic work of an 11-in. square supersonic wind tunnel, which until late in the War was the only supersonic tunnel of reasonable size available to the United Nations.

Despite these preoccupations, Smith found time for probably his most notable personal research, producing with Dr. W. A. Wood four papers on the application of X-ray methods to the study of the deformation and fracture of metals. It is, however, as an administrator of scientific research that he will be best remembered. In 1944, he became the first director of research of the British Shipbuilding Research Association, a post which he still held at his death. Under his leadership the Association has become the central research organization in Britain for the shipbuilding, ship-repairing and marine engineering industry. He organized the work of the Association in an unusual way; no laboratory was set up, but a wide variety of research contracts was placed with universities, other research institutions and industrial firms. Among many papers by Dr. Smith covering this work may be mentioned his Thomas Lowe Gray Lecture to the Institution of Mechanical Engineers in 1952 on ship research, that on the resistance experiments with the old Clyde steamer *Lucy Ashton*, modified for jet propulsion to avoid propeller drag, and recent papers on nuclear propulsion.

Smith was made C.B.E. in 1951. He had been a vice-president of the Institutions of Mechanical Engineers and of Naval Architects, and a member of many technical committees on marine (including nuclear) propulsion, structural steel, corrosion and other subjects, as well as of committees of other research institutions. D. G. Sopwith

Prof. H. J. Logie

Prof. H. J. Logie died on November 8 at the age of thirty-nine. His untimely death came at a period when his research had become very productive, and has been a shock and a great loss to all his colleagues and friends. He received his early education at Benoni High School, went to the University of the Witwatersrand as a student in 1936 and graduated bachelor of science in 1938 with firsts in both mathematics and physics. In 1939 he was awarded first-class honours in physics, and in

1940 he was appointed a junior lecturer in physics. He soon resigned in order to go on active service, and at the age of twenty-four attained the rank of major in the Special Signals Services (Radar) of the Union Defence Force.

Prof. Logie rejoined the University staff in 1946. Despite the very heavy teaching duties which the staff undertook on account of the large number of ex-Servicemen returning to South Africa, he took part in an active research programme in the recording of the Witwatersrand earth tremors. He was awarded the degree of doctor of science in 1949 for a thesis on this work.

In 1950 the staff of the Department of Physics agreed to form a team working together in the field of the physics of the solid state, and Prof. Logie spent a year studying the physics of metals in the University of Birmingham. On his return he started experimental and theoretical research on internal friction in metals and alloys. He was chosen as the first occupant of the newly established chair of experimental physics. On taking up his new appointment, Prof. Logie assumed responsibility for work on the changes of electrical resistivity produced by plastic strain in alloys, and on the electrical properties of counting diamonds.

In addition to teaching and research, Prof. Logie played a large part in other University activities, while outside the University he found time for many scientific and public services.

For the last seven years of his life he suffered from ill-health, but it was characteristic of the man that he spared himself so little as to make this generally forgotten. Friends will remember his lively wit and his warmth as a family man. F. R. N. NABARRO

Prof. F. A. Paneth, F.R.S.

PROF. H. DINGLE writes: "The obituary notice of the late Prof. F. A. Paneth in *Nature* of November 8 omits to mention one incident which is at the same time so characteristic of the man and so noteworthy in itself as to justify recalling. On his appointment to the chair of chemistry at the University of Durham, Paneth at once began to interest himself in the local scientific associations, and his attention was captured by the then shadowy figure of Thomas Wright, who first discerned the true character of the Milky Way and whose 'Original Theory of the Universe' (1750) was the source of the idea that inspired Immanuel Kant to write his 'Allgemeine Naturgeschichte und Theorie des Himmels'. With his customary energy and enthusiasm, Paneth brought to light a number of forgotten facts and neglected relics of Wright, discovered that two notices in Allibone's 'Dictionary of English Literature', ostensibly relating to two different persons, in fact referred to the same versatile Thomas Wright, and identified Wright's 'observatory' —a round stone tower which he had caused to be erected at Westerton, near Durham, of which the origin had been completely forgotten; it was known locally as the 'Westerton Folly'. Paneth succeeded in arousing public interest, and in June 1950, the two-hundredth anniversary of the publication of the 'Original Theory of the Universe' was celebrated by public meetings at which, among other events, a collection of Wright memorials was exhibited, a commemorative tablet affixed to the tower was unveiled, and a wreath was laid on Wright's grave. Durham has a special reason to honour Paneth's memory".

NEWS and VIEWS

Physiology at Aberdeen:

Prof. E. W. H. Cruickshank

PROF. E. W. H. CRUICKSHANK, who has recently retired from the regius chair of physiology in the University of Aberdeen, from which he graduated, is the living embodiment of the 'wandering Scot'. He graduated in medicine in 1910, and one year later he was in University College, London, with Starling. There he made the significant discovery that, in pancreatectomized dogs, the cardiac muscle, unlike skeletal muscle, stores glycogen. This work, however, was interrupted by the First World War, and it was not until 1919 that, at the invitation of the Rockefeller Foundation, he returned to academic life in the laboratory of Erlanger in St. Louis. He then went to the new Pekin Union Medical College, where he had his first experience of building up a new department from scratch. Yet he found time to continue his study of cardiac metabolism; he also worked on respiration and on general metabolism.

The year 1924 found him back in Britain, in Cambridge. Under the influence of Sir Joseph Barcroft, he showed that the spleen, in the dog at least, acts as a reservoir of blood. In collaboration with Anrep he put on a quantitative basis the coronary blood flow in relation to the activity of the heart. Then Cruickshank went to India as the first professor to build up a Department of Physiology and Biochemistry in the Prince of Wales Medical College at Patna. Two years later an invitation reached him to go to Dalhousie University in Nova Scotia. Here he had seven active and happy years devoted largely to research on metabolism of the heart—an authoritative article from his pen is to be found in Vol. 16 of the *Physiological Reviews*. The final 'call' came in 1935 when Cruickshank succeeded his friend, J. J. R. Macleod, in the chair at Aberdeen. Cardiac metabolism continued to be his main preoccupation, although he was also caught up in the general interest in nutrition and wrote a small book on this subject. In his later years, under the auspices of the World Health Organization, he has had the pleasure of visiting many medical schools in parts of the world where he himself had been a pioneer in establishing physiology as an academic discipline.

Prof. J. Laurence Malcolm

PROF. MALCOLM, who has recently succeeded Prof. Cruickshank in the regius chair of physiology in the University of Aberdeen, comes from New Zealand. His first degree was B.Med.Sci. of the University of Otago and he then proceeded to the M.B., Ch.B. in 1938—a proper emphasis on the scientific basis of medicine which unfortunately seems to find less support in Great Britain. While still an undergraduate, Malcolm demonstrated in physiology and studied on rats the goitrogenic action of certain diets. He spent

a year as house surgeon in a New Zealand hospital and another year as lecturer in the Department of Bacteriology and Public Health at Otago. In 1941 he became senior lecturer in experimental physiology at Otago, where he remained until 1948. There he came under the stimulating influence of Prof. J. C. Eccles, with the inevitable result that his subsequent work has been in the exacting and modern field of neurophysiology. Neurophysiologists suffer from the same disability as the early microscopists, they must design and build their own equipment.

During 1948–49 Malcolm held an exchange lectureship in St. Thomas's Hospital Medical School, London, and then the readership in physiology with Prof. Huggett at St. Mary's Hospital during 1949–52. The following year he was visiting professor in the New York State University at the invitation of Prof. Chandler Brooks. He then returned to the National Institute for Medical Research in London to the Division of Physiology and Pharmacology. There he used most ingenious and delicate electrophysiological methods to study activities in various parts of the brain: he was even able to study conditioned reflexes in unrestrained animals. The emphasis in the study of the central nervous system is rapidly changing from the anatomical and histological approach to the biochemical and pharmacological. In this new and exciting field Malcolm is using his special techniques to obtain records of the influence of various chemical substances on the brain itself.

Geography in the University of Hull: Prof. H. R. Wilkinson

The late Prof. Herbert King has been succeeded in the chair of geography in the University of Hull by Mr. H. R. Wilkinson, senior lecturer in geography in the University of Liverpool. Prof. Wilkinson was, like his predecessor, a pupil of Prof. P. M. Roxby in the Liverpool School of Geography, graduating with first-class honours in 1939, and in much of his work reflects that School's traditional interest in human geography. Following six years of war-service, he became senior geography master at Bootle Grammar School. He was appointed by Prof. H. C. Darby to the staff of the Department of Geography at Liverpool in 1947, where, following Prof. Wilfred Smith's sudden death in 1955, he was acting head of the Department for four terms. Prof. Wilkinson's special interests have lain in the fields of human geography and cartography, and he has much first-hand experience of Yugoslavia and adjacent areas of central and south-eastern Europe. His published works include "A Geography of Merseyside" (1948), "Maps and Politics: a Study of the Ethnographic Cartography of Macedonia" (1951), "Maps and Diagrams: their Compilation and Production" (with F. J. Monkhouse, 1952), and numerous papers in geographical and other journals. He was an assistant editor of "A Scientific Survey of Merseyside", the handbook prepared for the Liverpool meeting of the British Association for the Advancement of Science in 1953.

Prof. Wilkinson has served as a member of the Council of the Institute of British Geographers and was a member of the British delegation to the International Geographical Congress held in Washington, D.C., in 1952. He has lectured in Austria and Yugoslavia under the auspices of the British Council. To the growing Department of Geography at Hull he brings a varied experience and a wide range of interests in the subject.

The Inter-University Council for Higher Education Overseas

At the end of February, Mr. S. J. Worsley will complete his term of office as secretary of the Inter-University Council for Higher Education Overseas. Mr. I. C. M. Maxwell, assistant secretary of the Council since September 23, 1952, will succeed Mr. Worsley. Mr. Maxwell was formerly secretary of the University of London Senate Committee on Higher Education in the Colonies, a body responsible for the development and detailed working of the special relationship of the University of London and certain university colleges overseas. He has, therefore, had considerable experience of higher education in the Colonies and is well-known to members of the staffs of the universities and university colleges with which the Inter-University Council is associated.

Soviet International Press Censorship

Strong criticism of, and protest against, Soviet censorship of science reporters, especially British and American, have recently been made, according to Mr. Victor Cohn, science editor of the *Minneapolis Tribune*. This was particularly evident in connexion with the International Geophysical Year meeting in Moscow during July–August. Mr. Cohn states that Western correspondents had to file their reports in triplicate at the Central Telegraphic Agency in Moscow; these were censored and then returned to the correspondents "15 minutes or two hours or six hours or 24 hours later, or never". Mr. Cohn has given some examples of undesirable censorship exercised by the Soviet authority.

A group of correspondents wrote letters of protest to Prof. Sydney Chapman, president of the Comité Spécial de l'Année Géophysique Internationale. In one letter it was claimed that "in areas where the public of our nations is concerned, there can be no freedom of enquiry or scientific reporting unless there is also freedom to communicate with the public. It would seem intolerable to hold great scientific meetings in a place where their results cannot be communicated to the people who must support science in our countries". On August 5, Prof. Chapman replied: "It is the view of the C.S.A.G.I. bureau that the press should be able to transmit to the public the views of the participating I.G.Y. committee on purely scientific matters". The newspaper correspondents' protest seems justified, and Prof. Chapman's guarded reply encouraging. It is, to say the least of it, very frustrating when a correspondent cannot be sure that his report of a scientific meeting will be cabled, even after it has been held several hours. This form of press censorship, especially where international conferences and the like are concerned, is much to be deplored.

Science and History

"There is within you", said Hobbes, "some special cause of intenebration which you should do well to look to"; and Prof. Douglas McKie in his inaugural lecture delivered at University College, London ("Science and History." Pp. 17. London: H. K. Lewis and Co., Ltd., 1958. 2*s*. 6*d*. net), on May 22 has done us a service. The Department over which he has been called to preside was founded after the First World War as a virtual by-product of discussions centring around an institution for a diploma in journalism. After even further consideration a committee was appointed which recommended that the history of science should be a post-graduate discipline including the study of what was at first

method of science but has now become the philosophy of science. Instituted in 1924, it has now some sixty students, and its staff, of which Prof. McKie has been one of the outstanding ornaments, has made a name by careful and scholarly research. In these days as scientific journals increase at the rate of more than a thousand a year, synoptic views need more than ever to be authoritative. Prof. McKie's plea that the history of science should be recognized as a branch of history has already been tried by Dr. J. B. Conant, and University College, London, is trying, too. Looking further, he sees the expansion of this field in the history of technology reaching into the history of medicine. Prof. McKie's modesty makes his inaugural address pleasant reading; one only regrets that it does not include a little autobiography. He, of all men, should be encouraged to tell us of his own writings and work.

Cotton in the Prehistoric Southwestern United States

THE textiles, old or new, of particular areas have formed the subject of a number of reports published in recent years, which have an interest by no means limited to the areas with which they deal. The late Prof. Lila O'Neale's "Textiles of Highland Guatemala" was a notable example dealing with modern weaving, and a recent report (*Trans. Amer. Phil. Soc.*, N.S., 47, Part 3: The Cultivation and Weaving of Cotton in the Prehistoric Southwestern United States. By Kate Kent. Pp. ii+457–734. 4 dollars), which is concerned mainly with ancient examples, should command an equally wide interest, not only among textile specialists but also among those who are interested in New World archæology. The work has entailed widespread research among museum collections, as well as painstaking study of individual examples, many of them in poor condition. A great deal of this report naturally consists of descriptions of specimens, but the admirable drawings make it easy to follow the processes and to pick out what is of general interest. The bulk of the material available dates from between A.D. 1000 and 1400, but evidence is given for the use of the loom in the area at least as far back as A.D. 700. It may be remarked that it was far older in some other parts of America, and it will be surprising if it does not eventually prove to have reached the south-west of the United States at an earlier date. The account is not limited to loom-woven fabrics, and it includes such processes as twining, besides netting and other single-element techniques. It was found possible to distinguish the products of several sub-areas in the region.

Of particular interest are suggestions as to how and when various processes were introduced from Mexico from a possible ultimate source in Peru. Brief comparisons are made between looms and processes popular in Peru and the south-west of the United States; twills, for example, are common in the latter and rare in Peru, where warp floats enjoyed a vogue which was lacking farther north. The wide loom, horizontal or vertical, with fixed beams, was largely used alongside the belt loom in the south-west of the United States, whereas the belt loom predominated farther south, and the evidence for the use of a stationary loom in ancient Peru is still unsatisfactory. The Peruvians always had a taste for finger weaves, whereas there was a greater dependence on loom processes in the south-west of the United States. Observations of this sort direct attention to the desirability of a synthetic study of weaving in different parts of ancient America, a work which would be of great interest and value. This report would form one of its foundations.

Silver Jubilee of *Polarforschung*

THE Archiv für Polarforschung at Kiel has recently published two special issues of its journal, *Polarforschung*: one to celebrate the journal's twenty-fifth anniversary, and the other in memory of Alfred Wegener. Apart from special emphasis in the second on the German Greenland Expedition of 1930–31, these two issues follow the pattern of their predecessors. There are short articles on a wide variety of subjects; but scientific results of expeditions are not normally to be found here. The jubilee issue, for example, includes a summary of the weather at Vorkuta by an ex-prisoner there, a discussion of dreams during the polar night by a doctor, a survey of volcanic activity in Iceland since 1700, and many more notes further exemplifying this diversity. The somewhat austere layout and type face, together with the absence of diagrams or illustrations, should not deter the careful reader, who will find information of interest and value not available elsewhere. Polar specialists will be sorry to hear that Dr. Max Grotewahl, the founder and organizer of the Archiv für Polarforschung, died on September 6, shortly after the appearance of these two issues.

National Museum, Bloemfontein

THE annual report of the National Museum at Bloemfontein for the year ended March 31, 1958, (pp. 22. Bloemfontein: National Museum, 1958) records the completion of ten new displays, including dioramas of vultures, pan-life (birds), *Uranocentrodon* (fossil amphibian) and *Aulacocephalodon* (fossil reptile). Several minor building extensions have been undertaken, although no start has yet been made on the two new wings for the Museum. Four members of the staff are studying at and writing theses for the Department of Physical Anthropology in the University of the Orange Free State at Bloemfontein, and various grants-in-aid enabled the Museum to undertake large-scale excavations at the Matjes River rock shelter.

Uptake and Translocation of Radioactive Phosphorus in Plants

G. N. THORNE (*Annals of Botany*, N.S., 32, 381; 1958) has investigated and discussed the factors which affect the uptake of radioactive phosphorus by leaves and its translocation in the plant. The rate of uptake of phosphorus-32 from solutions of labelled sodium dihydrogen phosphate sprayed on to one leaf of swedes (*Brassica napus*) or french beans (*Phaseolus vulgaris*) was rapid during the first few hours and fell to zero after four days. Phosphorus-32 was detected in the root after 3 hr. and continued to move out of the treated leaf for at least six days after application. A larger fraction of the applied phosphorus-32 was absorbed from repeated than from a single spraying. Swedes absorbed more phosphorus-32 from a single application to the lower surface than to the upper surface of the leaf. Doubling the concentration of the spray caused a small increase in the percentage of applied phosphorus-32 that was absorbed. Absorption by french bean leaves decreased slightly when the area sprayed with a constant amount of phosphorus-32 was doubled, and decreased with increasing age of leaf. Increasing the supply of phosphorus to the roots of

swedes affected neither the initial rate nor the total uptake of phosphorus-32 by the leaves, but decreased the quantity of radiophosphorus that was translocated out of the treated leaf. Increasing the relative humidity of the air around the plants also increased uptake of phosphorus-32. Shading usually decreased uptake and always decreased translocation. Re-wetting the leaf to which the radiophosphorus had been applied, with water or sucrose solution, had variable effects.

Establishment of *Pythium* in Soils

R. Barton has reported that, whereas species of *Pythium* can be isolated from cultivated soils by using susceptible host seedlings as bait, they could not be isolated from woodland, non-cultivated or very acid soils (*Trans. Brit. Mycol. Soc.*, 41, 207; 1958). The behaviour of inocula of *Pythium mamillatum* in a cultivated (native) soil, and in a woodland (alien) soil was assessed by means of the host test described. Maize meal added to the cultivated soil became colonized by *P. mamillatum* after only two days, indicating that, under these conditions, the parasite behaves as a saprophytic 'sugar fungus'. In the alien woodland soil, *P. mamillatum* did not colonize maize meal. After neutralization of this acid soil with lime, however, the fungus rapidly utilized the material. The parasite could not be grown in culture at the low *p*H value of the alien soil. The behaviour of vegetative hyphæ of *P. mamillatum* in these contrasting soils was studied by the glass-fibre tape technique. In native, cultivated soil, oospores and resting sporangia were formed abundantly, whereas in alien woodland soil these bodies were not produced. Thus, the inability of *Pythium* hyphæ to produce a resting phase may prevent long-term survival of the parasite in alien soils. This effect was shown to be due to low *p*H value of the soil, which may directly limit the normal life-cycle of *Pythium* in acid woodland soils.

Researches on Tropical Vegetation

The scientific study of the rich and varied floras of tropical regions not only brings its own reward but also is of very real practical importance. The wise utilization of forested tropical lands is not merely something to be desired: it has been recognized as a problem of considerable urgency for many years, especially in regions of increasing population. A Unesco publication on humid tropics research entitled "Study of Tropical Vegetation" (written in both English and French. Pp. 226. H.M.S.O., 1958. 30*s*.), records the proceedings of a symposium held in Kandy, Ceylon, in 1956, and prepares the way for further investigations. Tropical forests, growing on soils of varying fertility, are the raw materials of agriculture, whether this be pursued piecemeal by small farmers or extensively by large plantation companies. Swamp and rain forests, though still of vast dimensions in some regions, are certainly not unlimited; and those on soils of fair to good inherent fertility tend to become a shrinking asset, especially in areas which offer easy or reasonable accessibility. Where this is so, and in conjunction with a rapidly increasing population, the problems of adequate agricultural production become progressively more acute; and research, combined with appropriate practical action, is seen to be essential. In the present report, some twenty-six technical papers contributed by specialists from thirteen countries give important indications as to what some of the basic problems are and how they may be tackled. In general, the coverage is what might be expected: tropical vegetation, in its many aspects, is described, mapped, illustrated and discussed, especially from the ecological point of view, and the relevant environmental factors analysed. The need for conservation under official auspices and for further study are strongly emphasized. The representative regional surveys and illustrations are specially attractive and valuable features of this volume.

Cocoa Conference 1957

Under the above title the Cocoa, Chocolate and Confectionery Alliance (11 Green Street, London, W.1) has published a comprehensive report (pp. xiv+326+35 plates. London: 1958. 63*s*.) giving the full texts of the papers presented at the international conference sponsored by the Alliance and held in London during September 10–12, 1957. The papers—nearly forty in number—are arranged under general headings corresponding to the sessions of the conference: commercial background; developments in new cocoa-growing areas, planting materials and methods; disease and pest control; chemistry of cocoa fermentation; preparation and quality; and the cocoa tree in its environment. These titl *s* show the scope of the conference, which brought together 282 delegates ranging from scientific workers in agriculture and food technology to representatives of industry and of government agencies. The majority of the participants were from different parts of the British Commonwealth, and two West African Governments—Ghana and Western Nigeria—were represented for the first time by Ministers. Delegates from different European countries and the United States were also present. This wide representation gave the conference its unique character. The report shows the efforts that have been, and are being, made by scientific workers in the laboratory and in the field to promote a branch of agriculture which is of vital importance to the economic stability of several Commonwealth—as well as other—territories overseas. The report will therefore be of value both to those actively concerned with the cocoa and allied industries and also to economists, agricultural scientists and others who are interested in the problems of the developing countries in Africa and elsewhere. Both these groups of readers will accept the report as an essential source book.

The Ciba Fellowship Trust

The Ciba Fellowship Trust has been founded by Ciba Clayton, Ltd., Ciba Laboratories, Ltd., Ciba (A.R.L.), Ltd., and the Clayton Aniline Co., Ltd., for the purpose of improving and increasing the interchange of ideas between scientists in the United Kingdom and on the Continent. The trustees are Sir Arthur Vere Harvey, Lord Hives, and Sir Alexander Todd. The fellowships will be awarded by an advisory panel, the members of which are Sir Arthur Vere Harvey (chairman), Prof. A. J. Birch (University of Manchester), Prof. W. Bradley (University of Leeds), Dr. A. Brunner (Ciba, Ltd., Basle), Dr. E. Brunner (Clayton Aniline Co., Ltd., Manchester), Prof. D. H. Everett (University of Bristol), Prof. D. M. Newitt (Imperial College of Science and Technology, London), Dr. R. F. Webb (Ciba (A.R.L.), Ltd., Duxford). Several fellowships will be awarded for tenure during the academic year 1959–60 at Con-

tinental universities or institutions for research in chemistry, physics or some other allied scientific subject. They will be awarded to graduates of universities in the United Kingdom or the Republic of Ireland. The basic award for Fellows who wish to continue postdoctorate studies will be £800 per annum plus allowances. For candidates who have obtained a first degree in science and wish to undergo training in research, the basic award will be £500 per annum plus allowances. The total value of each fellowship will be determined by the advisory panel, and will be sufficient to cover the Fellow's living and other expenses (including fees and cost of travel) during the tenure of his fellowship, which will be for one year, renewable for a further one or three years. Applications should be made in duplicate on forms obtainable from the Secretary of the Ciba Fellowship Trust, Ciba (A.R.L.), Ltd., Duxford, Cambridge. The closing date for such applications is January 31, 1959.

C.S.I.R.O. Wool Research Laboratories

THE three Wool Textile Research Laboratories of the Commonwealth Scientific and Industrial Research Organization (Australia) have been made divisions of the Organization. The Melbourne Laboratory becomes the Division of Protein Chemistry, the Sydney Laboratory the Division of Textile Physics, and the Geelong Laboratory the Division of Textile Industry. In future this group of divisions will be called the C.S.I.R.O. Wool Research Laboratories. These laboratories were established in 1949. The officer-in-charge of the Melbourne Laboratory, Dr. F. G. Lennox, becomes the chief of the Division of Protein Chemistry; the officer-in-charge of the Sydney Laboratory, Mr. V. D. Burgmann, becomes chief of the Division of Textile Physics; and the officer-in-charge of the Geelong Laboratory, Dr. M. Lipson, becomes chief of the Division of Textile Industry.

Annual Conference of Educational Associations

THE forty-second annual conference of Educational Associations will be held in the College of Preceptors, 2 and 3 Bloomsbury Square, London, W.C.1, during December 30–January 2. Dr. B. E. Lawrence, chief education officer, Essex, will deliver the presidential address entitled "Partnership in Education" on the eve of the Conference in the assembly hall of the Institute of Education, University of London. During the Conference, and under the auspices of the School Nature Study Union and the Universities Federation for Animal Welfare, Miss F. R. Elwell, science producer, B.B.C. Television for Schools, will give a lecture on "Animals and Television" in the College of Preceptors on December 31 at 2.30 p.m. All meetings at the Conference are open free of charge and without tickets. Further information can be obtained from the Conference Secretary, 2 and 3 Bloomsbury Square, London, W.C.1.

Geographical Association Summer Schools

THE Geographical Association is organizing two summer schools in 1959. The first, to be held in Spain during August 12–27, under the direction of Dr. M. J. Houston (Oxford), will deal with Mediterranean geography. On this course members will study the land-forms and vegetation climaxes on the northern and southern flanks of the central Pyrenees; contrasts in relief, vegetation and land use in the central cordillera of Spain (field excursions from Madrid); and distinctive types of land use and settlement in Valencia and Catalonia (field excursions from Valencia and Barcelona). Urban studies will be made in Madrid, Valencia and Barcelona. The second, to be in Switzerland during August 18–September 2, will consist of Alpine studies centred on Orsières in the Pennine Alps, near the Italian and French frontiers. It will be under the direction of Mr. R. C. Honeybone (London). Members will study the Alpine environment of the Drance River and its tributaries, and its physical and cultural relations with, to the north, the Rhône valley (Martigny and Sion) and, to the south, Val d'Aosta via Grand St. Bernard; a field excursion to study glacial features near Chamonix will be included in the programme. Members' field work and several of the field excursions will be done on foot, which will involve hill-walking and climbing but not rock-climbing. Further details and forms of application can be obtained from the Assistant Secretary, Geographical Association, c/o The Park Branch Library, Duke Street, Sheffield, 2.

University News: London

DR. J. A. LAING, reader in the University of Bristol, has been appointed to the Courtauld chair of animal husbandry and veterinary hygiene tenable at the Royal Veterinary College.

The title of professor emeritus of plant physiology in the University has been conferred on Prof. F. G. Gregory on his resignation on December 31 from the chair of plant physiology at the Imperial College of Science and Technology, which he has held since 1937.

Announcements

THE insignia of C.B.E. has been presented by the British Ambassador in Rome to Prof. Domenico Marotta. As director-general of the Istituto Superiore di Sanità in Rome, Prof. Marotta has an important position in chemical science and industry in Italy, and organized the meeting this year of the Eighth National Congress of the Italian Chemical Society jointly with the Society of Chemistry and Industry.

THE Worshipful Company of Founders has awarded its medal in bronze to the following Liverymen of the Company to mark "their services to the Art and Mystery of Founding and to the Company": Dr. J. G. Pearce, director of the British Cast Iron Research Association; Dr. J. E. Hurst, managing director of Bradley and Foster, Ltd., Darlaston; Mr. C. C. Booth, director of Booth and Brooks, Ltd., Burnham-on-Crouch; and Mr. J. J. Sheehan, lately managing director of the Coneygrw Foundry, Ltd.

MR. WILLIAM BARR has been nominated by the Council for election as president of the Iron and Steel Institute for the 1959–1960 session. He will take office at the general meeting on May 6.

IN February 1956 the National Metallurgical Research Laboratory of the Council of Scientific and Industrial Research, Jamshedpur, India, held a symposium on "Production, Properties and Application of Alloy and Special Steels". The forty-five papers contributed are now published (pp. vi+488. Jamshedpur: National Metallurgical Laboratory, 1958), and cover all the main aspects of the subject. Most of them are from Indian workers, but a dozen or so represent contributions from metallurgists in Europe and America.

THE NATIONAL CHEMICAL LABORATORY

THE National Chemical Laboratory, Teddington, of the Department of Scientific and Industrial Research, held a series of open days during October 21–24. In this article there is space to describe only some of the items on view.

Improved laboratory and semi-scale techniques for separating the rare earths have been developed, and considerable amounts of the individual oxides have been accumulated. Increased availability of these materials has prompted a search for new uses. A recent application of thulium was the subject of a very attractive display. When the pure oxide is irradiated in a high neutron flux, soft γ- and X-rays are emitted which can be used in engineering and medical radiography, and a number of interesting radiographs taken at the Atomic Energy Research Establishment, Harwell, were shown. The source unit consists of a small pellet of sintered thulia enclosed in an aluminium capsule.

The use of zone-refining for purifying materials used in researches on semiconductors, such as indium, tellurium, bismuth and aluminium, also attracted interest. The difficulties of following the course of purification by conventional analytical methods are considerable, and when possible, the movement of impurities is followed by introducing radioactive tracers; for example, the removal of silver from bismuth was effected by using radioactive silver as tracer. Other exhibits included the Department's collection of pure metals, and the recovery of valuable materials from industrial wastes.

In conventional processes for the extraction of uranium, it is necessary, after leaching the ore, to separate the barren solids from the uranium-bearing liquor; this liquid/solid separation represents a considerable percentage of the cost of extracting uranium. It has been found, with certain ores and with the correct degree of grinding, that satisfactory uranium extractions can be obtained by means of a limited contact between the aqueous leach pulp and the extracting solvent. This principle is employed in the disk contactor: the disks are wetted by the aqueous phase, and, as they rotate, a film of the aqueous solution is carried through the solvent, so effecting transfer of uranium.

Plastic standards for radiometric assay of uranium have been prepared by mixing 'Bakelite' moulding powder with pitchblende, the density of the standard being varied by addition of heavy fillers to the mixture before moulding. These standards, designed for use with prospectors' field ratemeters, possess the advantages that they are not liable to contamination or spillage and that they are not affected by changes in humidity or possible loss of radon.

Tests of the resistance of metals to corrosion and of the effectiveness of corrosion inhibitors are being made in water circulation systems at different speeds and temperatures of the water. The object of the work is to find means of reducing losses due to corrosion in industrial cooling systems.

*Cyclo*hexylamine carbonate has been applied by the Laboratory as a volatile corrosion inhibitor, and has given promising results in the protection of boilers and other steel equipment during shut-down periods.

The rate of oxidation of clean, pure iron is being measured by methods sensitive enough to detect the formation of less than one-tenth of a complete molecular layer of oxide per minute. The pressure in the apparatus can be controlled from less than 10^{-8} mm. mercury upwards.

Among various physico-chemical equipment for the examination of organic compounds was a simplified double-beam infra-red grating spectrometer using a 'Merton – National Physical Laboratory' replica as the dispersing element. The instrument is intended for chemical applications, both in analytical and structural diagnosis. The design allows solvent compensation to be achieved, and expansion of any part of the scale as required.

The stock of standard organic compounds available for distribution now includes fifty-five individual compounds. During the year, 395 samples were sent out to forty-five laboratories.

There is considerable interest at present in the development of materials of improved thermal stability for use as plastics, lubricants, hydraulic fluids, surface coatings, etc. A variety of organometallic compounds shows promise in this connexion, and work on this project has recently been initiated at the Laboratory. At present, attention is mainly directed to the boron–nitrogen and related systems.

Novel types of redox resins have recently been developed at the Laboratory. These resins are capable of undergoing true electron-exchange, that is to say, operating reversibly on an oxidation-reduction cycle. The new materials displayed were based on cellulose and polyvinyl alcohol and some of their potential applications were illustrated.

A knowledge of the molecular weights and molecular-weight distributions of commercially important polymers is of great importance to the polymer industry. A comprehensive survey of work in progress included the determination of the molecular weights and shapes of polymers by viscometry, osmometry, light-scattering photometry, and ultracentrifugation. Other exhibits showed the results of fractionation of polymers according to their chain-lengths, and the molecular weight distribution curves derived from these experimental studies.

Another facet of the work, namely, research on the synthesis of new types of ion-exchange resins and membranes, was also shown. Materials of this type are of great value in water treatment and extraction of valuable organic and inorganic substances from solution.

Microbial activities which have economic importance are also being studied. One extraordinary microbe needs no organic food—it lives on a simple diet of sulphur, mineral salts and air, and produces strong solutions of sulphuric acid. This organism is responsible for extensive damage to concrete structures such as water-cooling towers and sewage conduits. The use of sulphate-reducing bacteria to produce sulphur from sewage sludge and gypsum was illustrated. Demonstrations were given of the preservation of pure cultures of bacteria by freeze-drying; the bacteria can be revived after many years with unchanged properties. The number of strains held by the National Collection of Industrial Bacteria is about 1,100, from which 1,700 cultures were sent out during the past year.

FUNDAMENTAL RESEARCH IN SAFETY GLASS

THE Fundamental Research Laboratory of the Triplex Safety Glass Company at Holly Grange, Balsall Common, held an 'At Home' on November 14, to show the progress made since its official opening in December 1957. The main objective of the Laboratory is to establish the fundamental scientific background to safety glass manufacture and especially that of the toughened or tempered types which are produced by heat treatment. The work of the Laboratory falls roughly into four sections: toughened glass structure; physical chemistry; optics; and mechanical properties.

Work on the determination of the atomic structure of heat-treated glasses was shown in the X-ray, Electron-Microscopy and Thermodynamics Departments. Of special interest in connexion with X-ray investigations was a microdensitometer designed and built in the Laboratory.

Methods of producing safety glass by chemical means involving ion- and atom-exchange were shown in the Physical Chemistry Laboratory. Experimental low-temperature alloys for use as bus-bar material in glasses coated with gold film were also on view.

The work displayed in the optics section included stress measurements on toughened glass using Babinet and Sénarmont methods, together with interferometric methods of measuring the thickness of thin metallic films on glass. This latter was in connexion with the use of gold films, approximately 60 A. thick, which are used as heating elements on aircraft and other windscreens. Micro-hardness techniques to evaluate the surface properties of glass with special reference to abrasion resistance were also shown, together with apparatus for determining the light transmission of aircraft windscreens.

The results of investigations towards producing safety-glass components with less scatter in mechanical properties were on view in the Heat Treatment and Mechanical Properties Departments, where the application of schlieren methods for the study of the action of air jets used in the quenching process evoked much interest. The application of strain-gauge techniques to the evaluation of stress occurring in large glasses was also demonstrated.

THIRD INTERNATIONAL SEAWEED SYMPOSIUM

THE third International Seaweed Symposium was held in Galway, Ireland, during August 13–15, when some 220 scientists and industrialists from twenty-seven countries in Europe, Asia, Africa and the Americas attended. (The first and second Seaweed Symposia were reviewed in *Nature*, **170**, 478; 1952; and **176**, 1106; 1955.) The symposium was opened by Mr. Seán Lemass, Minister for Industry and Commerce, who welcomed the delegates to Ireland.

Our knowledge of the physical structure of the cell-wall of many algae has been greatly increased within recent years by new techniques such as polarization microscopy, electron microscopy and X-ray diffraction analysis, and these were reviewed by Prof. R. D. Preston (England). The chemistry of the polysaccharides of the brown, red and green algae was covered by Prof. E. L. Hirst (Scotland), and Dr. H. M. Ulrich (Austria) dealt specifically with alginic acid and its derivatives both from the chemical and industrial points of view.

Nine papers were devoted to the chemistry of the carbohydrates, proteins and other constituents of the red algae. Low molecular compounds were discussed by Mr. B. Wickberg (Sweden). Further interesting glycosides have recently been isolated; for example, '*iso*floridoside' is a mixture of diastereoisomers (1-O-α-D-galactopyranosyl D- and L-glycerol), while O-α-D-galactopyranosyl (1 → 6)-O-β-D-galactopyranosyl (1 → 1)-glycerol, which occurs in wheat flour lipids, has been found in two red algae. Dr. J. R. Turvey (Wales) dealt with the polysaccharides of *Porphyra umbilicalis*, which include a galactan sulphate, floridean starch, mannan and xylan; the galactan sulphate contains D-galactose, 6-O-methyl-D-galactose and 3:6-anhydro-D-galactose. 3:6-Anhydro-galactose is now a common constituent of red algal galactans. 6-O-Methyl D-galactose has been isolated from several *Porphyra* species, and Dr. J. C. Su (Formosa) reported its presence in *P. crispata*. The mucilage of *Gloiopeltis furcata* appears to be composed chiefly of agarobiose units, as in the case of the main polysaccharide ('agarose') of agar-agar. Prof. P. S. O'Colla (Ireland) discussed the constitution of the mucilage from *Laurencia pinnatafida*, which contains galactose, xylose, galacturonic acid and sulphate; the branched structure contains a 1:3-linked galactan backbone. A somewhat similar structure has been assigned to the gelatinous polysaccharide of *Furcellaria fastigiata*. Dr. E. G. Young (Canada) pointed out the many difficulties encountered in examining the amino-acids, peptides and proteins of *Chondrus crispus*; about 20–30 per cent of the protein nitrogen could not be solubilized, but the distribution of amino-acids in this insoluble protein was similar to other algal proteins; 80 per cent of the total nitrogen extracted was dialysable. Dr. Young also discussed the stability of carragheenin in dried *C. crispus*, which is of considerable importance to the seaweed industry; intrinsic viscosity and gel strength decreased markedly after storing the weed at 4°, 10° and 20° C. for two years, indicating degradation of carragheenin in the plant. Mr. M. O. Reachtaire (Ireland) read a paper on phycoerythrin and phycocyanin, and the absorption spectra and structure of these chromoproteins were discussed. Dr. C. Ó hEocha (Ireland) described the occurrence and distribution among a number of red algae, particularly in the Rhodomelaceae, of four water-soluble fluorescent substances; these were extracted, separated by chromatography, and characterized by their absorption spectra. One compound from *Laurencia pinnatafida* was obtained in crystalline form and its probable structure determined.

The polysaccharides of *Acrosiphonia centralis*, a green alga closely related morphologically to *Cladophora rupestris*, were reported by Dr. E. Percival (Scotland); partial hydrolysis of a sulphated polyuronide gave chiefly glucose, xylose, rhamnose and oligouronic acids composed mainly of rhamnose and glucuronic acid, and comparisons were made with the polysaccharides from *C. rupestris* and *Ulva lactuca*. Present evidence suggests that the green algae are the most complex from the chemical point of view.

Several communications were devoted to alginic acid and the alginates. The seventy-fifth anniversary of its discovery was marked by a short biographical sketch of E. C. C. Stanford by Dr. T. Dillon (Ireland). The seasonal variation in the alginic acid content of *Ascophyllum nodosum* was discussed by Mr. D. T. Flood (Ireland), while the effect of species, habitat, pre-treatment of the seaweed and isolation procedures on the viscosity of alginate solutions was covered by Mr. A. Haug (Norway). Methods for determining alginic acid were reviewed by Mr. M. F. Van der Lande (France), and details of the copper acetate and a new potentiometric titration method were given. The precipitation of sodium alginates of different degrees of polymerization by salts of lead, calcium, nickel and manganese was shown by Mr. R. H. McDowell (England) to be a complex problem and highly dependent on alginate concentration. The birefringent properties of alginate and carrageenate with colloid cations, for example polyglucosamine, were demonstrated by Dr. L. Langmaack (Germany), and there is a possibility that the phenomenon known as *Symplexionotropie* may be responsible for the formation of ordered structures in the plant *in vivo*. Dilute acid extracts of some brown algae contain phenolic reducing compounds known as 'fucosan', which are located in the physodes and are responsible for the brown colour formed in alkaline seaweed extracts; the fucosan content of *A. nodosum* was reviewed by Mr. A. Haug (Norway), and the influence of habitat on this and other constituents was discussed by Mr. B. Larsen (Norway), who also gave details of the influence of season, habitat and age of tissue on the niacin content of brown algae. The minimum number of plants required to give a representative sample for chemical analysis has been a vexed question for many years; in a paper on the statistical analysis of a large number of *Laminaria cloustoni*, Mr. F. T. Walker (Scotland) suggested 120 plants grouped according to haptera levels.

Both chemical and enzymic methods for removing sulphate groups from carbohydrates are of extreme importance in the elucidation of structure of the many algal polysaccharide sulphuric esters, and these were reviewed by Dr. P. F. Lloyd (Wales), who went on to describe the action of the sulphatases of *Patella vulgata* on fucoidin, chondroitin sulphate and keratosulphate. Further work in this field is awaited with interest. The use of the mass spectrometer in carbohydrate problems was outlined by Mr. P. A. Finan (Scotland); the potentialities of this ionization technique are immense in structural and conformational studies. Dr. C. C. Burt (Scotland) described the results of animal experiments with sodium laminarin sulphate as a blood anticoagulant; in rabbits and dogs, single doses of 20 mgm. per kgm. were well tolerated, but daily injections over 1–2 weeks produced toxic symptoms; the cause of this toxicity was discussed.

The occurrence and utilization of algae in the Caribbean and Morocco were discussed by Mr. W. D. Richardson (British West Indies) and Mr. G. Apikian (Morocco), respectively. The value of two New Zealand species, *Pachymenia himantophora* and *Durvillea antarctica*, as a fertilizer was assessed in a paper read by Mr. M. O. Reachtaire (Ireland). The interesting work being carried out in Norway on the use of seaweed meal as a supplement in animal feeding-stuffs was reported at the last symposium; Prof. J. Höie and Mr. A. Jensen (Norway) described further trials with chicks, hens, rats and sheep. The attitude of industry towards the research institute was assessed by Mr. E. Booth (Scotland) with particular reference to seaweed.

Critical observations on the taxonomy, ecology, growth and development of single species of marine algae formed the basis of several papers presented in the botanical sessions of the symposium. Dr. P. S. Dixon (England) showed that season and environment cause considerable morphological variation in *Pterocladia pinnata*, with the result that there has been taxonomic confusion in this species. Considerable variation was also noted by Dr. G. T. Boalch (England) in pure cultures of *Ectocarpus confervoides*, grown under different physiological conditions. The culture, growth and differentiation of *Caulerpa prolifera* were discussed by Prof. W. P. Jacobs (United States), who carried out experimental work on this species in the Naples Marine Laboratories.

Little has been reported on the effects of growth substances on the growth and development of marine algae. Dr. L. Provasoli (United States) found that, in bacteria-free cultures of *Ulva lactuca* (in sea-water media enriched with vitamins), the initiation of new germlings and the length of atypical filaments were increased by the combination of kinetin and indolacetic acid. Conspicuous elongation of the filaments was promoted by the addition of gibberellins to the kinetin–indolacetic acid combination.

An interesting account of *Monostroma* culture in Japan was given by Prof. T. Segi (Japan). It was shown how the results of a study of zoospore development in this species were of value to those concerned with its commercial culture. It is used for food as 'Aonori'.

The effects of environment on the development of *Fucus vesiculosus*, growing on an exposed shore and in an enclosed bay, were explained by Prof. W. R. Müller-Stoll (Germany).

Mr. H. T. Powell (Scotland) proposed that of the fifteen or so *Fucus* species currently recognized in various parts of the world, only five (or six) should be accorded specific rank. The species are *Fucus serratus* L., *F. vesiculosus* L., *F. ceranoides* L. emend., *F. spiralis* L. emend. (or *F. sherardii* Stackhouse emend., still being investigated), *F. distichus* L. emend. Powell, and perhaps *F. virsoides* J. Agardh.

Studies of the growth of *Macrocystis pyrifera* at various depths in the sea were reported by Prof. F. T. Haxo (United States), who has developed techniques and instruments which should prove useful in similar studies of other attached seaweeds.

Mr. B. Grenager (Norway) explained how he was able to predict the distribution of *Laminaria digitata* f. *stenophylla* and *Ascophyllum nodosum* in unknown areas on the Norwegian coast, by a study of charts only. The predictions were later substantiated by field surveys.

Nitrogen fixation by terrestrial blue-green algae is well known, but as Dr. M. B. Allen (United States)

pointed out, little is known of nitrogen fixation by marine organisms. Dr. Allen gave an account of how she is growing pure cultures of freshwater nitrogen-fixing, blue-green algae under saline conditions, and reported the effect of this on their capacity for nitrogen fixation.

Dr. M. R. Droop (Scotland) discussed evidence for and against the view that vitamin B_{12} may become a limiting nutrient for phytoplankton populations in the sea. The mass culture of marine phytoplankton was reviewed by Dr. G. E. Fogg (England), who concluded that it was unlikely to become a practical proposition, at least until harvesting difficulties could be overcome.

Dr. J. W. Kanwisher (United States) reported on a new method of continuous oxygen recording which has been used for measuring the photosynthetic and respiratory capacity of several intertidal algae.

Details of a method of physode estimation were given by Dr. E. Baardseth (Norway), who found that the percentage physode volume varied from species to species and in *Ascophyllum*, with variation in salinity and habitat.

Prof. H. A. von Stosch (Germany) discussed similarities between the leucosin of diatoms and chrysomonads and the laminarin of Phaeophyta. He gave evidence to support the conclusion that these substances are closely related.

The main symposium was followed by a single-day symposium on "Intertidal Ecology".

The time available for discussion following each paper was very limited, but there were ample opportunities for private discussion at the various shore-collecting excursions and social functions run in connexion with the symposium. It was agreed that the complete text of the papers presented should not be published. The fourth International Seaweed Symposium is to be held in France in September, 1961, and an Advisory Committee consisting of Prof. T. Braarud (Norway), Dr. T. Dillon (Ireland), Prof. T. Levring (Sweden), Dr. A. D. de Virville (France), Dr. F. N. Woodward (Great Britain) and Dr. E. G. Young (Canada) was appointed to assist the French National Committee in drawing up a programme.

W. D. Richardson
E. T. Dewar

INTERNATIONAL CONFERENCE ON SCIENTIFIC MEASUREMENTS

An international conference on the theoretical and practical problems involved in making scientific measurements was held in Budapest during November 24–29. Part of the conference was held in the building which was formerly the Stock Exchange but is now the home of the engineering societies and is re-named Technika Háza. The other meetings were held in the Rózsa Ferenc House of Culture. Some 250 foreign and 460 Hungarian scientists took part in the conference, and representatives came from twenty-three countries. Academies of science in a number of countries, including France, Italy and Sweden, either sent representatives or gave their official support to the conference.

Some 160 papers were read, 127 of them by non-Hungarian scientists. The papers were divided into a number of sections with the following titles: mechanical and optical, electrical and electronic, thermal, physico-chemical and nuclear-physical. There were also papers on the economics of instrument production, and an informal discussion was held between the university teachers present to discuss student courses for measuring techniques and instrument-making. Though there were many papers of considerable individual merit, one difficulty emerged during the conference, namely, that in some sections the papers were too diverse in character to form a coherent whole. Summaries of most of the papers were published in two booklets, mostly in the German language, though some were given in English, French or Russian.

The Hungarian Chamber of Commerce arranged an exhibition of Hungarian scientific instruments in the Technika Háza. The well-known skill of Hungarians in arranging exhibitions was clearly shown here. Though there were gaps in the range of instruments exhibited, the level of instrument technology in the fields covered appeared to be high.

This conference was called by three organizations acting jointly, one Hungarian, one in the Soviet Union and one in Poland. The Presiding Council hopes to prepare a further conference, probably in 1961, and to enlarge the national representation on the committee which will organize it.

Visits to scientific institutes in the Eötvös Lorand and the Technical Universities and in the Academy of Sciences were arranged. There was also a social programme which included visits to the opera, theatre and cinema. Those attending the conference were very conscious of their debt to the members of the staff of the Hungarian Federation of Scientific Societies for the care which they took in ensuring the comfort and the convenience of visitors.

W. A. Wooster

THE FUTURE OF ANTARCTICA

"That a new era in Antarctica indeed is opening needs clearer recognition. Suddenly Antarctica now has applied to it the resources, the techniques and the wealth of experience from no less difficult operations in the Arctic. The United States pre-eminently, and Russia not far behind, both possess and feel it expedient now for the first time to use great resources in Antarctica on a scale without precedent. Their northern experience is immense. Yet great resources of men and materials are not deployed by even the very powerful without strong reasons."

"Political stability in Antarctica in the next few years is certainly improbable. The post-war realignment of the nations in terms of modern power and resources is now in process of extending to Antarctica. . . . Now is the time for realism and re-appraisal by the sovereign states of Antarctica."

These quotations from the published version* of the lectures delivered by Dr. G. C. L. Bertram while he was William Evans visiting professor in the University of Otago in 1957 indicate well the nature of his theme. Dr. Bertram, who was director of the Scott Polar Research Institute at Cambridge during 1949–57, speaks with authority about Antarctica, and in this thought-provoking essay he speaks with evident concern. He recognizes and discusses five motives that may underlie rational activity in Antarctica—the adventurous, economic, scientific, political and strategic motives, and from his discussion there emerges a picture of the present situation in which the last two named are dominant, a situation in strong contrast to that which obtained in the first twenty years of this century when British expeditions dominated the Antarctic scene and interest was primarily adventurous and secondarily scientific. Dr. Bertram examines the probable motivation of the twelve nations that may be said to-day to have Antarctic 'aspirations' or 'interests'. Five of these—Australia, France, Great Britain, New Zealand and Norway—lay formal claim to sectors of Antarctic territory which cover about four-fifths of the continent. The sovereignty of these five mutually recognizing Powers is, however, not admitted by the United States and the U.S.S.R., the two Powers deploying greatest resources in the Antarctic, and is openly flouted by others. Time, Dr. Bertram insists, is not upon the side of the five, and their position is not helped by their comparative grave weakness in shipping suitable for the maintenance of their Antarctic interests. "Not one of the five," he remarks, "has the full manœuvrability and appearance of power only to be given by the possession of a genuine ice-breaker. On the other hand, Russia, the United States and Argentine have admirable such vessels, and even Chile has building a ship superior to anything possessed or yet being built by the five. Our grandfathers must turn in their graves at this astonishing change in maritime power and forethought and at the depths to which the British Commonwealth has sunk." There is an over-riding need, Dr. Bertram thinks, for consultation by the five, and first and especially by the three Commonwealth countries, and a re-appraisal leading to a constructive plan. "When the passage of time may seem to give advantage to the rival or adversary, then it is often rationally expedient to seize the initiative."

Dr. Bertram considers some of the theoretical possibilities for the future political evolution of Antarctica, namely, recognition of existing claims (and here he notes how much this would be aided if the United States even now were to lay claim, as it has excellent reason for doing, to the remaining unclaimed Pacific sector); sale of Antarctic territory; condominium, possibly under the United Nations Organization; partition into territories each administered by members of the United Nations in trust; and finally, what he calls the "functional approach" whereby the powers of existing international and technical organizations, such as the International Civil Aviation Authority or the World Meteorological Organization, should be recognized as providing the effective authority within their spheres of activity. This functional approach is attractive, but whatever the mode of evolution favoured, Dr. Bertram is clearly right in calling for some immediate and realistic thinking, both in Britain and in the Commonwealth, concerning our Antarctic aspirations and responsibilities.

David L. Linton

* Antarctica Today and Tomorrow. By Prof. G. C. L. Bertram. Pp. ii+28. (Cambridge: At the University Press; Melbourne: Melbourne University Press, 1958.) 5s. net.

ROTHAMSTED EXPERIMENTAL STATION

REPORT FOR 1957

Every year, when reading the annual report of the Rothamsted Experimental Station*, one is impressed anew by the scope of the work undertaken by Britain's oldest agricultural research centre. Not only British but Commonwealth problems receive regular attention, a fact well shown by the list of overseas visits and secondments of staff for the purposes of specialist consultation or investigation. The present report is the fiftieth of the series, and a valuable inclusion is a summary index covering this period. It is, indeed, a concise history of the development of Rothamsted in the present century.

Comprising, as it does, the work of fifteen departments as well as such activities as soil surveys at home and abroad, it is not possible for any single reviewer to discuss critically all the varied information contained in the report. The main lines along which research is proceeding may, however, be indicated.

In the Physics Department work has continued on the structure and properties of soil, particularly clays. Studies on these suggest that, when they are wetted slowly, subsequent flooding does not produce the slaking effect that it has on a dry clay and that the shattering effect of entrapped air seems to be very slight. The practical effect of this seems to be that, in a saturated atmosphere, the slaking action of rain on dry field soil is confined to the surface, since the diffusion of water vapour downwards ahead of the liquid wetting front permits a controlled swelling of the clay without disruption. Other investigations have dealt with temperature and water relations in soil and with crop environment with particular emphasis, during the period under review, on spring wheat. It has been shown that short-period fluctuations in the rate of water uptake by wheat follow closely the changes in sunlight intensity.

The Chemistry Department has continued its experiments on the use of fertilizers and it is clear that seasonal variations in crop response to nitrogen are so large that it is not yet possible to make practical recommendations to the farmer with the certainty that he would like. This is not surprising since the maximum profit from any particular crop does not depend on one factor alone. One interesting finding was that heavy dressings of calcium nitrate

* Rothamsted Experimental Station (Lawes Agricultural Trust). Report for 1957 (With 50-Year Index, 1908–57). Pp. 316. (Harpenden: Rothamsted Experimental Station, 1958.) 10s.

damaged germination and early growth of all crops, while under the same conditions an equivalent amount of ammonium sulphate was harmless. Alternatives to superphosphate have been tested, but none so far has proved superior to this well-tried substance, a fact, surely, that would have gratified Rothamsted's founders. Work has continued in the Pedology Department on the mineralogy of soil components, the determination of which is of great help to the Soil Survey. Materials from Britain and from abroad have been studied, and a number of unusual minerals identified.

The nitrogen cycle and the ecology of soil micro-organisms remain the two major interests of the Soil Microbiology Department. The relationship between *Rhizobium trifolii* and its phage has been studied, and changes in the latter have been noted during storage in artificial soil. A fungistatic action by certain aerobic spore-forming bacteria has been demonstrated in all soils examined except those with a strong acid reaction, and it is suggested that such bacteria may be responsible for fungistasis in natural soil in the field. Other investigations have concerned the bacterial decomposition of herbicides and cellulose.

Various aspects of plant nutrition and growth have continued to interest the Botany Department, particularly the effect of nutrients on root and leaf growth. The known relation of leaf area to crop yields makes such studies of considerable practical interest. The effects of nitrogen, phosphorus and potassium on leaf area have been examined, as was that of gibberellic acid. The effect of this last was one of increasing the leaf area rather than the photosynthetic activity of the plant. A foliar application of gibberellic acid to potato increased leaf area and crop yield but caused some malformation of the tubers.

Plant enzymes engaged the attention of the Biochemistry Department, and an article on "Bracken Thiaminase" by R. H. Kenten is included in the report. This study has not yet produced results of practical application in bracken eradication, but a useful and necessary start has been made in acquiring the basic knowledge essential to a solution of this most important agricultural problem.

The contribution of Rothamsted to our knowledge of plant viruses is universally appreciated and needs no advertisement. The Plant Pathology Department is as active as ever in this field and much detailed and fundamental research continues. Electron microscopy has added much to our knowledge of viruses, but advances in technique are needed for this tool to be fully exploited. Possibilities in this direction are under continuous examination, and the published work of the Department is proof of the progress made in this very critical matter. In addition to the better-known plant viruses, those of cereals and grasses have received attention. Yellow dwarf virus is increasing in cereal crops in Britain, but more needs to be known concerning its effect on yield. Results recorded here suggest that this is more severe on oats than on wheat and barley. The susceptibility of various grasses to infection by cereal viruses and the identification of their vectors have also been studied.

Work on eelworms of economic importance and their predators has been the concern of the Nematology Department, while the Insecticides and Fungicides Department has continued the study of the pyrethrins and the effect of environmental conditions on the toxicity of various insecticides and fungicides.

The Entomology Department is working on various aspects of the biology and ecology of insect pests, in particular, aphids, frit fly, gall midges and the wheat bulb fly. The study of the behaviour, physiology, nutrition and the diseases of bees has been continued by the staff of the Bee Department.

Statistics have always figured largely in the work of Rothamsted, and the installation of an electronic computer has increased both the range and the volume of the work of the Statistics Department. In addition to work on the Station's own experimental data, help has been given to outside institutions in planning experiments and analysing results.

The report includes a list of the field experiments now in progress on the Rothamsted and Woburn farms and an account of the year's progress in the Soil Survey of England and Wales. Accompanying the article on bracken thiaminase already mentioned are papers by Mary D. Glynne and G. A. Salt on "Eyespot of Wheat and Barley" and by R. G. Warren on "The Residual Effects of the Manuring and Cropping Treatments in the Agdell Rotation Experiment".

The list of contributions to scientific journals made during the year with which the report ends bears evidence of the industry with which current problems are being investigated at Rothamsted and are a tribute to all concerned. J. H. WESTERN

EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANIZATION

REPORT FOR 1957

THE East African Agriculture and Forestry Research Organization is an inter-territorial research organization administered by, and forming part of, the East Africa High Commission. It is jointly financed by the three East Africa Territories of Kenya, Tanganyika and Uganda, the Protectorate of Zanzibar and the United Kingdom Government through the Colonial Development and Welfare Fund. The principal functions are to undertake long-term research work on behalf of the Territorial Departments of Agriculture and Forestry or to investigate problems which require highly specialized equipment or research officers. The present report (East Africa High Commission: East African Agriculture and Forestry Research Organization. Record of Research for the period 1st July, 1956, to 31st December, 1957. Pp. vii + 112. (Nairobi: Government Printer, 1958.) Sh. 3/50) describes examples of each of these types of work and contains much of interest to all those concerned with agriculture and forestry in the

tropics. The Physics Division in collaboration with the plant physiologist has continued to investigate the water relationships of plants and soils, and in particular have been concerned with problems associated with the most economical use of available water. This work also involves calculation of the amount of water which crops use from week to week, from simple meteorological and basic soil data. The prediction of crop responses of the soil and the build-up of nitrates in the soil due to decomposition of soil humus are two important aspects of the work of the Chemistry Division. It has now been shown that soil humus may be divided into two parts. One part is held by the soil and is resistant to decomposition even if the soil is kept warm and moist. The other much smaller part is in the soil solution and oxidizes rapidly under these conditions. Humus comes into solution when a dry soil is wetted, and the drier the soil before wetting the greater the amount of organic matter coming into solution. Thus, nitrates are only produced in the soil in appreciable quantities during the first rains after the dry season, and if leaching occurs there is not likely to be appreciable production of new nitrate later on. This emphasizes the need to get crops established as early as possible in the wet season. The Plant Pathology Division, starting with Central American varieties of maize, has successfully completed a breeding programme to give varieties resistant to tropical American maize rust, *Puccinia polysora*, a disease which first occurred in East Africa in 1952. Forestry investigations are mainly concerned with problems in the drier areas of East Africa. The Animal Nutrition Division has made extensive analyses of the main organic components of several local grasses at different times of the year, and the apparent digestibility of these grasses has been compared with those from temperate regions. Collecting of botanical specimens has actively continued and the services of the herbarium for identification of specimens has been in great demand from neighbouring territories.

ELECTRON RESONANCE STUDY OF THE RADICALS PRODUCED BY CONTROLLED POTENTIAL ELECTROLYSIS OF AROMATIC SUBSTANCES

By D. E. G. AUSTEN, Dr. P. H. GIVEN, Dr. D. J. E. INGRAM and M. E. PEOVER

British Coal Utilisation Research Association, Leatherhead, Surrey
and
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THE negative ions formed by electron transfer from sodium metal to hydrocarbon molecules in tetrahydrofuran solution have received much attention in the past year or so, and recently studies have been extended to the similar ions formed in the same way by carbonyl, nitro and cyano derivatives[1]. The same radical-ions have been postulated as the primary products of the polarographic reduction of aromatic hydrocarbons in dioxan-water[2] and of aromatic carbonyl compounds in the non-proton-active solvent dimethylformamide[3]. These inferences from polarographic behaviour have not hitherto been supported by any direct demonstration that the ions are indeed present. We wish to report such a demonstration, obtained by measuring the electron resonance signal given by solutions electrolysed under the polarographic conditions.

Anthracene, benzophenone and anthraquinone have been electrolysed (the apparatus and method are described in ref. 4) in 0·1 *N* tetraethylammonium iodide in dimethylformamide, using a stirred mercury cathode the potential of which was maintained at a value corresponding to the top of the first wave of each substance[4,5]. Under these conditions the polarographic evidence indicates that the paramagnetic mononegative ions should be formed (Fig. 1):

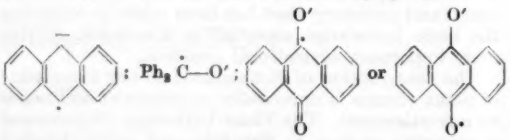

Fig. 1

At intervals during the electrolyses, samples were withdrawn under oxygen-free nitrogen into tubes of a size to fit the resonant cavity exactly. The tubes were immediately chilled in liquid nitrogen and sealed, and the signal was measured, a few hours later, in a 3-cm. wave-length electron resonance spectrometer. This employed an $H_{01\delta}$ rectangular cavity cooled to liquid-oxygen temperatures, and obtained high sensitivity by magnetic field modulation at 100 Kc./s., and phase-sensitive detection[6]. The

Table 1. Details of Reaction Conditions and the Products

Substance	$-E_{1/2}$ (volt) versus mercury pool	Controlled potential (volt)	n*	Concentration of solution (mM)	Max. concentration free radicals (mM)	Nature of product	Line-width (gauss)	g-value ($\pm$ 0·001)
Anthracene	1·41, 1·88	− 1·55	2	40·1	0·31	Dihydroanthracene	18	2·005
		− 1·55	—	28·1	0·30			
Benzophenone	1·22, 1·47	− 1·3	2	33·0	0·83	Benzhydrol	19	—
Anthraquinone	0·33, 0·90	− 0·5	1	12·7	18	Equimol. mixture anthraquinone + 9 : 10-diacetoxy-anthracene†	11	2·007

* n = Faradays of electricity/mole of reducible substance. † Product was acetylated.

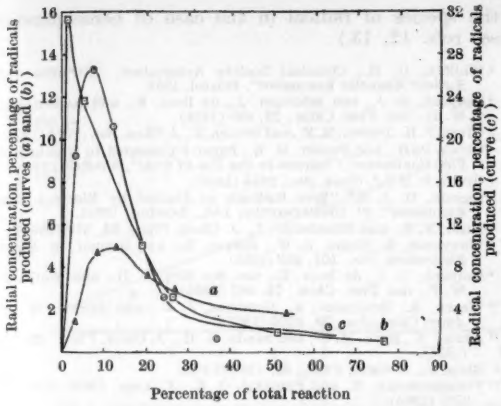
Radial concentration, percentage of radicals produced (curves (a) and (b))
Radical concentration, percentage of radicals produced (curve (c))
Percentage of total reaction
a
b
c

Fig. 2. Concentration of free-radical-ions as a function of degree of reduction: (*a*), Anthracene, 7·14 gm./l. (△); (*b*) anthracene, 5 gm./l. (□); (*c*) benzophenone, 6 gm./l. (○)

concentrations of free radical were calculated by comparing the integrated signal strengths with those from standard samples, and the absolute accuracy of the results is estimated at about ± 20 per cent. The number of radicals produced by electrolysis was calculated from the quantity of electricity passed, which was measured with a coulometer.

Details of the experiments are shown in Table 1. Appreciable concentrations of radicals were found in the solutions of all three substances. Since the measurements were all made on materials in the solid state, considerable anisotropic dipolar broadening was present and no hyperfine structure was observed. The magnitudes of the line widths were found to vary somewhat with dilution, confirming the fact that dipolar interaction was the main source of broadening. It is seen that the anthraquinone radical-ion has a *g*-value appreciably shifted from that of the free spin (2·0023), and this suggests that there is some localization of the unpaired electron in this case.

The results are shown in Fig. 2, where the concentration of radicals in each sample is expressed as a percentage of the total number produced at the cathode up to the time of withdrawal of the sample (it should be noted that for anthracene and benzophenone this fraction could not exceed 50 per cent since, according to the mechanism to be described, all the molecules of aromatic substance are on the average reduced twice). 'Total reaction' signifies the passage of 1 or 2 Faradays per mole, as indicated in Table 1.

Anthracene and benzophenone gave the dihydro products in good yield although the controlled potential was less than that required for two-electron reduction; there was no evidence of dimerization. The curves show that the radicals produced from these substances are consumed fairly rapidly. It has been shown[7] that disproportionation of hydrocarbon mononegative ions:

$$2\,R' \rightleftharpoons R + R''$$

is energetically not feasible. We therefore suggest the following mechanism to account for the observations (Fig. 3):

$$R + \varepsilon \quad = R' \qquad (1)$$

$$R' + \text{solvent} \quad = RH\cdot \qquad (2)$$

$$\text{either } RH\cdot + R' \quad = RH' + R \qquad (3a)$$

$$\text{or } RH\cdot + \varepsilon \quad = RH' \qquad (3b)$$

Fig. 3

Reactions 2 and 3*a* occur in the bulk of the liquid; the first of these must require activation and therefore be slow (that this is the mechanism of proton addition has been established[8] already). Hoijtink *et al.*[3] have shown that the radicals $RH\cdot$ derived from hydrocarbons always have higher electron affinities than the parent hydrocarbon molecules; moreover, electron-transfer reactions of the type of 3*a* are known to be rapid and not to require activation (for example, refs. 9, 10). Reaction 3*a* is therefore likely to be more important than 3*b*, and the $RH\cdot$ radicals will not make any significant contribution to the total concentration of radicals measured. The molecule *R* produced in 3*a* returns to the electrode and is reduced again. The difference in the results obtained in the two experiments with anthracene is probably due mainly to differences of temperature; heat is evolved during the electrolysis and an appreciable rise in temperature occurs in the early stages of reduction. Since the initial concentrations were different and moreover cells having cathodes of different area were used, the temperature history would have been different in the two experiments. If the temperature could be controlled, it would be possible to deduce the rate of protonation of *R'* from the results of experiments of this kind. The solvent used contained a small amount of water as impurity, but its molar concentration was less than one-fifth of that of the organic solutes, so that it cannot have made much contribution to the protonation by reaction 2.

The behaviour of anthraquinone is quite different from that of the other substances. Only 1 Faraday per mole was consumed. The concentrations of radicals measured in six samples collected during the electrolysis were very high; the values obtained were in fact all more than 100 per cent of those calculated from the initial concentration and the quantity of electricity passed, and rose from 109 to 150 per cent. These errors are mostly outside the expected limits of accuracy of the measurements and are difficult to account for. Some samples of the electrolysed solution were kept at room temperature for 6 hr. before measurement, and the observed concentrations of radicals were an appreciable fraction (20–40 per cent) of those obtained for the samples preserved in liquid nitrogen. This confirms that the rate of decay of radical concentration is small, and justifies the view

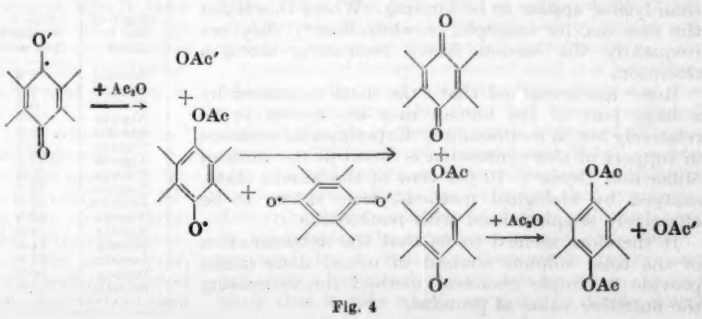

Fig. 4

that the fractional concentration is near 100 per cent throughout the electrolysis and that no protonation occurs. In order to facilitate identification of the product, acetic anhydride was added at the end of the electrolysis. The sequence of reactions shown in Fig. 4 can account for the result (that is, two moles free-radical-ion giving one mole each of the quinone and 9 : 10-diacetoxyanthracene).

Although the anthraquinone radical was stable enough to be examined at room temperature, it was not possible to observe any hyperfine structure, owing to lack of homogeneity in the magnetic field under the conditions that were used. The paramagnetic resonance spectrum of the 'semiquinone' of anthraquinone has been reported previously[11]; hyperfine structure was resolved and a g-value of 2·00403 quoted. However, it is not clear whether the species studied was the semiquinone itself or the semiquinone ion or the undissociated sodium salt. (For various views on the species of radical in the case of benzoquinone see refs. 12, 13.)

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A CORRELATION BETWEEN SULPHUR CONTENT AND NET DIETARY-PROTEIN VALUE

By D. S. MILLER and D. J. NAISMITH

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WITH the work of Willcock and Hopkins[1] and Osborne[2] the concept was established that the nutritive value of proteins could be interpreted in terms of amino-acid composition, or, in the light of more recent work[3], in terms of their content of essential amino-acids, and might therefore be estimated by chemical means.

Complete amino-acid analysis has much to commend it theoretically, but the methods available are frequently less accurate, more time-consuming and more expensive than the biological measurements used to monitor them. Furthermore, the most accurate amino-acid analysis of a protein does not necessarily provide an unequivocal basis for determining its nutritive value, or even the amino-acid limiting its value.

Attention has recently been focused on specific indispensable amino-acids in proteins. Of the chemical methods in current use, the measurement of 'available lysine' in protein concentrates, used in animal feeding, is most promising[4], but from inspection of the composition of human diets, containing proteins from many sources, the sulphur-containing amino-acids, methionine and cysteine together, rather than lysine, appear to be limiting. Where this is not the case (as, for example, in white flour[3]), they are frequently the second factor restricting nitrogen retention.

Rose[5] has remarked that "the diets consumed by a large part of the human race are known to be relatively low in methionine". Experimental evidence in support of this contention is found in the work of Miller and Dema[6]; 70 per cent of the human diets, assayed by biological methods, were shown to be effectively supplemented with methionine.

It therefore seemed to us that the determination of the total sulphur content of mixed diets might provide a simple chemical method for estimating the nutritive value of proteins.

A preliminary examination of biological data, taken from Block and Mitchell[3], and chemical figures from the food tables of McCance and Widdowson[7], relating to some twenty-five foodstuffs, revealed a correlation between their sulphur content and net protein value. (The correlation coefficient was 0·913; $P < 0·001$.) By common usage, net protein value (= biological value × digestibility × per cent crude protein) is determined on animals fed semi-synthetic diets containing the test protein at 10 per cent level. In the present experiments, the biological measurements were made by the method of Miller and Bender[8], using freeze-dried human diets from various parts of the world. To avoid confusion in terminology, since these materials were fed without any artificial adjustment in composition, net protein value is here termed net dietary-protein value[9], and the diet is evaluated in terms of reference protein[10].

Total sulphur was determined by combustion of the material in a Berthelot–Mahler bomb, precipitation of the sulphuric acid so formed with benzidene hydro-

Table 1

Origin of diet in meal	6·25 × nitrogen (per cent)	Net protein utilization (per cent)	Net dietary-protein value (per cent)	Sulphur (mgm. per cent)
Senegal	2·9	45	1·3	34
Senegal	8·4	39	3·3	82
Jamaica	5·5	66	3·6	90
Nigeria	8·0	53	4·2	109
Gambia	11·2	44	4·9	121
Nigeria	10·5	52	5·5	130
Nigeria	13·8	41	5·7	128
Nigeria	11·3	56	6·3	145
Gambia	17·8	38	6·8	172
Jamaica	12·2	60	7·3	169
Nigeria	13·5	59	8·0	194
Nigeria	16·0	52	8·3	186
Britain	14·4	61	8·8	185
Jamaica	17·8	58	10·3	197
Britain	16·6	68	11·3	197
Britain	17·9	69	12·4	263

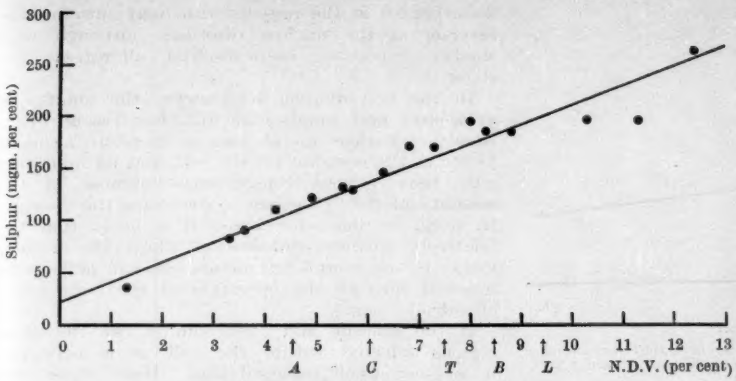

Fig. 1. Correlation between total sulphur content and net dietary-protein value (N.D.V.). Letters indicate 'safe practical allowance' for: *A*, adult; *C*, child; *T*, toddler; *B*, adolescent; *L*, lactating mother. N.D.V. = 0·0521 *S* − 1·06

chloride[11], and titration of the precipitate with standard sodium hydroxide[12].

The results are summarized in Table 1 and Fig. 1. Despite a wide variation in the percentage of crude protein and net protein utilization, a highly significant correlation between net dietary-protein value and total sulphur was found ($R = 0{\cdot}967$; $P < 0{\cdot}001$). In Fig. 1 this relationship is illustrated graphically, together with an indication of the 'safe practical allowance' for various age groups, calculated from the Food and Agriculture Organization report[10] by Platt and Miller[13].

In measuring total sulphur, no account is taken of the level of inorganic sulphate in the diet, the relative proportions of methionine and cysteine, or of the availability of these amino-acids. In addition, no allowance can be made with this method, or in fact with any chemical method, for the metabolic wastage of protein occurring at high levels of protein intake. It is, however, considered that none of these factors, with the possible exception of the last-mentioned, is likely to cause any serious error when dealing with complete human diets or meals.

We suggest, therefore, that the chemical method described above may provide a rapid means of assessing the nutritive value of proteins in human diets. As a further simplification, most of the chemical information may be abstracted from published data.

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STUDIES IN SYNTHESIS OF DEOXYRIBONUCLEIC ACID

Radiobiochemical Lesion in Animal Cells

A MULTIPLICITY of biochemical changes have by this time been described in animals following lethal or sub-lethal exposure to X-radiation[1]. It may now be appropriate to see if any unification of these changes is possible.

The response detectable in an intact animal is complicated by the presence of dead cells and by the adjustments occurring within the tissues following X-radiation. These adjustments may include migration of cells, proliferation of surviving cells, etc., so that the interpretation of biochemical effects later than 1–2 hr. after exposure is very difficult. We are therefore only concerned here with disturbances which can be detected immediately after irradiation and with the effects of these biochemical changes in radio-sensitive and non-sensitive cells.

Reactions associated with two sites within the cell appear to be affected shortly after exposure.

1. (*a*) Phosphorylation of nucleotides bound by the nucleus[2] is 100 per cent inhibited 3 min. after 50–100 r.[3]. Such phosphorylation has so far been demonstrated in rat lymph nodes, thymus, spleen, intestinal mucosa and bone-marrow, but not in liver, brain, kidney and pancreas. (*b*) The well-established reduction of precursor uptake into deoxyribonucleic acid is detectable in rat thymus after as little as 25 r. and is 49 per cent of the control value by 3 min. after 1,000 r.[4,5].

2. (*a*) Rat spleen deoxyribonuclease II, which is present in either the mitochondrial or the lysosomal fraction of cell homogenates, is liberated into the supernatant fraction by 30 min. after 850 r.[6]. (*b*) Mitochondrial oxidative phosphorylation is uncoupled[7,8]. With succinate as substrate the effect is detectable in rat spleen mitochondria 4 hr. after 100 r. and in rat thymus mitochondria after 50 r. After 700 r. the reduction is apparent by 2 hr.[9]. (*c*) After irradiation, phosphorylation by spleen mitochondria responds[9,10] to added cytochrome *c*.

Synthesis of deoxyribonucleic acid is a property of dividing cells, and evidence has gradually been accumulating that this does not occur continually through the life of the cell but is restricted to certain periods. The work of Howard and Pelc[11] on bean-root tips and Lajtha and his colleagues[12] with human bone-marrow cultures has indicated that synthesis of deoxyribonucleic acid occurs during a limited period in interphase—the synthetic period (*S*)—which is preceded by a highly radiosensitive pre-synthetic period (G_1) but which is itself less sensitive. It seems likely that in cells which are going to divide changes

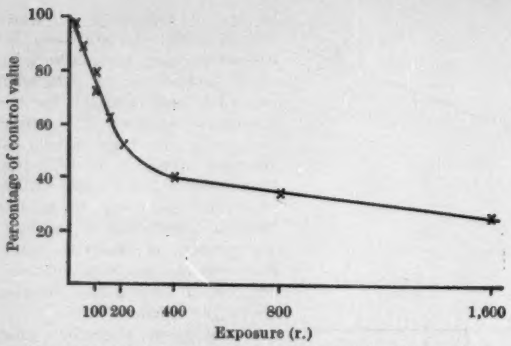

Fig. 1. The effect of total-body X-radiation on the incorporation of phosphorus-32 into rat thymus deoxyribonucleic acid 2 hr. after exposure

occur in G_1, which are an essential preliminary to the synthesis of deoxyribonucleic acid, and their inhibition by X-radiation would result in a failure of precursor uptake into deoxyribonucleic acid. The radiosensitivity of nuclear phosphorylation makes it attractive to suggest that this process may contribute to the radiosusceptibility of the pre-synthetic period. Either the phosphorylation of bound nucleotides is an essential preliminary to the synthesis of deoxyribonucleic acid, or the inhibition may be a delicate index of structural or functional changes within the nucleus not previously detected in other biochemical tests. Once the essential preliminaries have been completed, that is, the cell is entering S, higher exposures are required to prevent the final condensation of deoxyribonucleotides on the template.

A polyphasic response of synthesis of deoxyribonucleic acid to X-radiation is suggested from our results on the incorporation of phosphorus-32 into rat thymus deoxyribonucleic acid. The results show (Fig. 1) a very sensitive linear reduction in incorporation after 25–200 r., which is followed by a slowly increasing inhibition up to 3,200 r. It does not seem unreasonable to suggest that the initial portion of the dose–response curve corresponds to inhibition of nuclear phosphorylation and that the phase of only slowly increasing inhibition can be associated with progressive damage to the template.

A similar conclusion to this has also been reached by Lajtha, Oliver, Berry and Noyes (following communication) from autoradiographic studies of human bone-marrow cells exposed to either X-rays or α-particles in tissue culture.

These two facets of damage to the nucleus cannot be considered in isolation from the remaining part of the cell. The significance of the cytoplasm in the radiation injury has often been emphasized[12–15] and an excellent discussion of the relevant data has been provided recently by Trowell[16]. Alterations to mitochondrial reactions after exposure develop rather more slowly than those to the nucleus, but they lead to a decrease in production of adenosine triphosphate and to the liberation of enzymes, such as deoxyribonuclease II, which can exacerbate the nuclear damage. It seems probable that differences in radiosensitivity between dividing cells, lymphocytes and, for example, the liver, may be attributed to the part which the cytoplasm, and in particular the mitochrondria, can play in restoring or bypassing damage to the nucleus. In a dividing cell it is obvious that nuclear damage can prevent multiplication and, if rather large exposures are used, disturbances in the mitochondria may prevent any reversal of the nuclear disorders, although with smaller exposures mitochondrial alterations are slight.

In the non-dividing lymphocyte the volume of cytoplasm and number of mitochondria are very small[16]. Nuclear metabolism is therefore a major factor in the economy of the cell, and its inhibition may have serious consequences because of the inability of the cytoplasm to overcome the damage. In liver, on the other hand, it is likely that the relatively smaller contribution which the nucleus makes to the overall cell metabolism can perhaps be restored through the operation of the large mitochondrial reserve.

If the nucleus and mitochondria are the main regions affected within the cell, it is necessary to explain their susceptibility. Both these sites require oxygen and contain 'bound nucleotide'. Allfrey and Mirsky[17] have shown that treatment with deoxyribonuclease prevents nuclear phosphorylation, which may be restored by the addition of either deoxyribonucleic or ribonucleic acid, and Siekewitz and Watson[18] have suggested that bound nucleotide plays some part in mitochondrial oxidative phosphorylation. Ribonucleic acid–protein complexes are found in microsomes, and bound nucleotides may be part of the cell membrane; but neither of these latter sites appears to be radiosensitive. It may be the participation of oxygen, possibly in some bound form, in nuclear and mitochondrial reactions which is the factor determining the sensitivity of these sites.

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Mechanism of Radiation Effect on the Process of Synthesis of Deoxyribonucleic Acid

Synthesis of deoxyribonucleic acid occurs only for a limited period of time in interphase[1,2]. Therefore, in studying the effects of radiation on the synthesis

of deoxyribonucleic acid it is important to differentiate between effects on the pre- or post-synthetic period as opposed to the synthetic period itself (process of deoxyribonucleic acid synthesis). A previous publication[2] dealt with the effects of radiations on the pre-synthetic period (G_1 period); the present report is concerned with effects on the period of synthesis of deoxyribonucleic acid (S period) itself.

Human bone-marrow cell suspensions obtained by sternal puncture were used. The methods of culturing such suspensions *in vitro*, of high-resolution autoradiography, and planchette counting have been described previously[3–5]. 300-kV. radiation was employed (HVL 2 mm. copper) with a dose-rate to the cells of 480 rads/min. Sodium formate labelled with carbon-14 (4 μc./μM) was added to the medium 1·25 μc./ml. as deoxyribonucleic acid label.

As previously mentioned[3], in human bone-marrow cells *in vitro* the duration of the period of synthesis of deoxyribonucleic acid is about 12 hr. In short-term (1½–4 hr.) incubation with formate labelled with carbon-14 more than 85 per cent of the cells which collect sufficient amount of label for a visible autoradiograph will have been in the synthetic period at 0 hr. Irradiation of such short-term cultures therefore measures the effect of radiations on the period of synthesis of deoxyribonucleic acid directly; this could be an inhibition of synthesis as well as a reduction in the rate of synthesis.

The relative biological efficiency of α-particles compared with X-radiation was measured by dissolving radon gas in the medium in which the cells were suspended. For such irradiations, small (7-ml.) culture bottles were used for cutting down the air space above the fluid. Within 30 min. 500–5,000 rads could be delivered by the α-particles to the cells; the radon gas was then removed by aeration and the cell suspensions were transferred to the regular culture bottles for incubation with formate labelled with carbon-14.

Synthesis of deoxyribonucleic acid was measured by the average grain count per labelled cell, or by the total radioactivity in 12×10^6 cells. Previous experiments have shown that in such short-term incubations with the doses of radiation employed, the proportion of labelled cells does not change; it is the grain count over the labelled cells, that is, the amount of deoxyribonucleic acid synthesized per cell during the time of incubation, which is depressed by radiation.

The time relationship of depression of synthesis of deoxyribonucleic acid produced by a dose of 2,000 rads X-rays is shown in Fig. 1. It indicates that: (*a*) after 2,000 rads synthesis of deoxyribonucleic acid in the cells proceeds at about half the normal rate; (*b*) extrapolation of the slope of the reduced rate of synthesis intersects the control line at about 30 min., below which time presumably no depression is measurable.

The dose–response curve for X-rays on synthesis of deoxyribonucleic acid during a 4-hr. incubation period is shown in Fig. 2. (*a*) The pooled results of fifteen experiments (●——●) suggest that the curve of depression of rate of synthesis of deoxyribonucleic acid with increasing dose can be analysed in terms of two exponential components, one with a steep slope (S_1) and the other with a shallow slope (S_2). (*b*) The dose for 63 per cent depression for the S_1 component is about 500 rads, that for the S_2 component 13,000 rads. (*c*) In any single experiment a dose of 2,000 rads may produce as little as 30 per

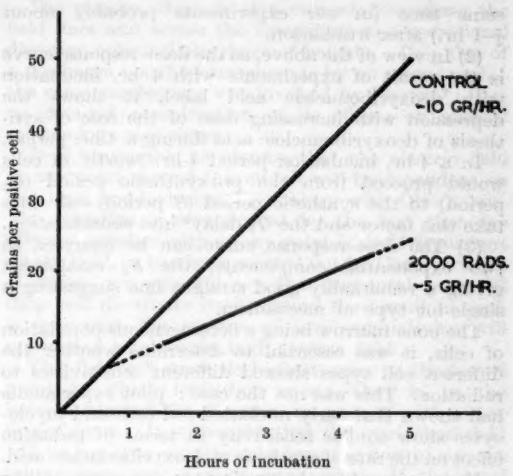

Fig. 1. Variation with time of depression of synthesis of deoxyribonucleic acid by a dose of 2,000 rads X-rays. Mean of four experiments

cent or as much as 65 per cent depression (mean 50 per cent), but the slope of the S_2 component remains the same (—). (*d*) Extrapolation of the mean S_2 slope intersects the scale at 40 per cent depression, but in different experiments it intersects at between 20 per cent or 60 per cent depression. (*e*) The relative biological efficiency for radon α-particles at 500 and 5,000 rads was found to be about 0·5.

The experimental error of any single point on the above curves is scarcely greater than the black circles on the main curve.

It is emphasized that in these experiments practically all the cells investigated were in their period of synthesis of deoxyribonucleic acid (S period). The results, therefore, refer to effects of radiation during the period of synthesis of deoxyribonucleic acid, that is, as nearly as is possible at present, to the process of synthesis of deoxyribonucleic acid in the cell.

(1) The time relationship of depression of synthesis of deoxyribonucleic acid shows that up to 4½ hr. after a dose of 2,000 rads synthesis of deoxyribonucleic acid is not stopped, but proceeds at a reduced rate. The term 'rate' is defined here as the amount of deoxyribonucleic acid label collected per cell during unit time. It also shows that this decreased rate of synthesis does not become apparent until

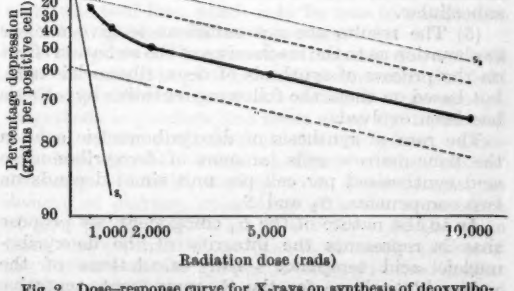

Fig. 2. Dose–response curve for X-rays on synthesis of deoxyribonucleic acid during a 4 hr. incubation period. ●——●, mean of fifteen experiments; ——, minimum and maximum curve (in single experiments)

some time (in our experiments probably about ¾–1 hr.) after irradiation.

(2) In view of the above, as the dose–response curve is the result of experiments with 4 hr. incubation with deoxyribonucleic acid label, it shows the depression with increasing dose of the *rate* of synthesis of deoxyribonucleic acid during a 4-hr. period.

In a 4-hr. incubation period 4-hr. 'worth' of cells would proceed from the pre-synthetic period (G_1 period) to the synthetic period (S period)—all data take this factor and the G_1 delay[3] into consideration.

(3) The dose–response curve can be analysed as two exponential components, the S_2 component giving a remarkably good straight line suggesting a single-hit type of mechanism.

The bone marrow being a heterogeneous population of cells, it was essential to determine whether the different cell types showed different sensitivities to radiation. This was not the case: pilot experiments had shown that early nucleated red cells and myelocytes show similar sensitivity in terms of radiation effect on the rate of synthesis of deoxyribonucleic acid.

Even in counting the myelocytes, one is not dealing with a pure clonal strain of cells, and therefore theoretically differences in radiosensitivity could be expected. However, in that case the dose–response curve would indicate two sharply different populations of myelocytes, one with a 37 per cent dose of 500 rads, the other of 13,000 rads. This sharp difference in the slopes of the components makes an explanation based on population differences very unlikely.

(4) A mechanism which results in decreased rate of synthesis of deoxyribonucleic acid per cell with increased dose of radiation (and not elimination of cells from synthesis of deoxyribonucleic acid) indicates that subcellular 'targets' are involved. Although the mechanism of damage is not yet clear, the exponential dose–response curve encourages one to consider a single-hit process, and to calculate the corresponding 'vulnerable volume' (a perhaps more fitting term than 'target', under our experimental conditions) from data given by Lea[6]. Thus, a relative biological efficiency of 0·5 between X-rays and radon α-rays leads to an individual volume of $4{\cdot}8 \times 10^{-3}$ μ^3 (ref. 6, Fig. 11), and a 63 per cent depression dose of 13,000 rads for X-rays would indicate 1,500 of these volumes per chromosome, a total of $7{\cdot}2 \times 10^{-3}$ μ^3 (ref. 6, Fig. 8*a*), corresponding to a total volume of $3{\cdot}3 \times 10^{-3}$ μ^3 per cell. Alternatively, these results can be considered to indicate a vulnerable volume in the form of a long filament, about 54 A. × 3·25μ per chromosome[6]. Even considering the very tentative nature of such calculations it seems clear that the dimensions are very much subcellular.

(5) The results are not sufficient to give a clear explanation as to the mechanism of the radiation effect on the process of synthesis of deoxyribonucleic acid, but based on them the following tentative hypothesis has been evolved.

The rate of synthesis of deoxyribonucleic acid in the bone-marrow cells (amount of deoxyribonucleic acid synthesized per cell per unit time) depends on two components, S_1 and S_2.

As to the nature of the S_2 component, we propose that it represents the integrity of the deoxyribonucleic acid template. Our calculations of the vulnerable volume for the S_2 component, tentative as they are, are compatible with such a concept. If, however, the nature of the radiation damage in S_2 is the breaking of the deoxyribonucleic acid double helix, then a dose of 10,000 rads should break only 0·1–0·5 per cent of the deoxyribonucleic acid molecules (mol. wt. 6×10^6 in a cell; Butler, J. A. V., personal communication). As Fig. 2 indicates a depression of at least 50 per cent due to the S_2 component alone at 10,000 rads, this may indicate that a larger functional unit is inactivated if a fraction of the deoxyribonucleic acid molecules in it is damaged—such a unit may be a part (or whole) of a chromosome. If enough parts of chromosomes (or whole chromosomes) are rendered incapable of synthesis of deoxyribonucleic acid, then the cell will synthesize: (*a*) less deoxyribonucleic acid per unit time; and (*b*) less than the full diploid amount of deoxyribonucleic acid per synthetic period.

As to the nature of the S_1 component, it may be part of the biochemical mechanism of precursor synthesis. At this stage it is not known whether the S_1 damage is destruction of an enzyme, or liberation of inhibitory substances, but it may well be a mechanism similar to that suggested by Ord and Stocken (previous communication). The delay in time of appearance of the S_1 damage may indicate destruction of an enzyme which produces some key compound. After destruction of the enzyme the cell would have to use up the compound made before destruction of the enzyme, before the lack of the compound becomes measurable. In different cells this time may be different, depending on the amount of compound available after the destruction of the enzyme. Apparently, in different cells the amount of the S_1 component may vary: a dose of 2,000 rads which destroys the S_1 component may result in only 30 per cent or as much as 60 per cent depression of the rate of synthesis of deoxyribonucleic acid. According to this concept, destruction of the S_1 component may slow down the rate of synthesis of deoxyribonucleic acid in the cell without necessarily preventing the synthesis of the full diploid amount of deoxyribonucleic acid. Experiments are in progress to elucidate the nature of these components.

(6) It has been known that in studying radiation effects on synthesis of deoxyribonucleic acid *in vivo*, changes in cell population or mitotic inhibition may obscure the picture. It was pointed out[3] that, even *in vitro*, interference with cell-cycle processes (elongation of the pre-synthetic period) have to be taken into account. It appears that even if all these are considered, the rate of synthesis of deoxyribonucleic acid in the cell depends on more than one factor. Until all these are elucidated one cannot interpret radiation effects in biochemical terms.

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LETTERS TO THE EDITORS

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Electric Field Theory of Auroræ

FROM time to time theories of the aurora have been proposed which invoke locally developed electric fields as the mechanism causing acceleration of solar particles into the relatively low levels of the ionosphere at which visible aurora usually occurs. However, these theories have been concerned mainly with an explanation of the classical idealized magnetic storm, treating the auroral phenomena as a by-product, and not attempting any detailed explanation of auroral morphology. One notable exception is the recent work of Chamberlain[1], in which an attempt has been made to explain the luminosity-height characteristics of an auroral ray in terms of an electric field in the ionosphere. The purpose of this communication is to present a crude qualitative description of the development of a typical auroral display as a result of the growth of an electric field in the ionosphere.

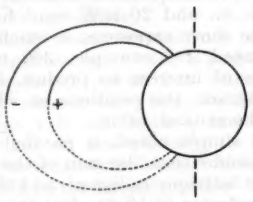

Fig. 1

Fig. 1 shows two lines of the geomagnetic field intersecting the Earth's surface in auroral-zone latitudes. Let us suppose that a potential difference is applied between these lines at their outermost extension as shown, without for the moment considering how this voltage is set up. The electrical conductivity of an ionized gas with an applied magnetic field is not isotropic[2], the conductivity transverse to the field lines being less than that along the field lines by a factor:

$$\frac{\nu^2}{(\omega_H^2 + \nu^2)}$$

where ν is the collisional frequency and ω_H is the radian gyrofrequency in the magnetic field. The values of ν and ω_H will be dependent on the type and charge of the particles under consideration, but we will restrict ourselves meanwhile to considering the electrons in the gas. At distances of the order of the outermost extent of the field lines, the collisional frequency is extremely small, so that the current flow will be strictly along the field lines, and the conductivity will be very large due to the long mean free path. As we penetrate the ionosphere, the conductivity transverse to the field lines will gradually increase since ν increases more rapidly than ω_H. The actual value of this transverse conductivity at any height will, however, also depend on the electron density at that height, and will vanish completely below the E-region, where the night-time electron density becomes zero.

The picture, then, is of a current flow along the field lines and across the ionosphere in a meridional direction over a finite range of heights. This idea of a discharge via the ionosphere is by no means new—the same mechanism was invoked by Martyn[3]; but no detailed consideration of its effects on auroral morphology was given.

It is reasonable to assume that the electric field at any point around this circuit will be dependent on the local conductivity, by analogy with Ohm's law. The situation is complicated by the fact that the effective conductivity at any point is itself dependent on the field, as has been pointed out by Chamberlain[1]. However, we can still say that the total potential drop will distribute itself around the circuit in such a way that the regions of low conductivity will experience a relatively high electric field.

This field will reach its highest value at the lowest point at which ionization exists, that is, at the bottom edge of the E-region in contact with either line of force. It is thought that the meridional field will be less than this because here the flow of current takes place over a very large area. If the total potential drop is now allowed to increase steadily, we shall start to see visible light first at E-region heights, corresponding to excitation of the air molecules. The appearance would be that of a homogeneous arc lying along a parallel of geomagnetic latitude. The important factor here is not the field alone, but the product of field and mean free path ($E\lambda$). By considering the energy distribution of electrons in an electric field, Chamberlain[1] has derived the expression:

$$J = kN(E\lambda e)^{3/2} \qquad (1)$$

for the current density, J. Here k is a constant, N is the electron density and e is the electronic charge. From this we obtain:

$$E\lambda = \frac{1}{e}\left(\frac{J}{kN}\right)^{2/3} \qquad (2)$$

Equation (2) shows us that as we travel up from the E-region into regions of increasing electron density, $E\lambda$ decreases, so that a relatively large drop in potential would be necessary to produce excitation. However, it is conceivable that at very great heights, N again becomes so small that $E\lambda$ can reach excitation proportions. Since the atmosphere probably contains a large proportion of hydrogen at these heights, we might see a glow of hydrogen emission which would appear to the south of the arc, due to the bending over of the field lines as shown in Fig. 1. This reasoning, of course, assumes that J is constant along the field line, which may be true to a sufficient degree of accuracy for our purposes.

If the potential continues to increase, the arc will start to extend vertically, until eventually the field in the meridional direction reaches a large enough magnitude to produce ionization along the horizontal portion of the path through the ionosphere. Once this happens, the total resistance of the 'circuit' decreases suddenly, leading to a large increase in density of current, coinciding with the appearance of light across large areas of the sky. At the same time, the conductivity of the horizontal portion of the circuit becomes greater in comparison with that of the vertical portion, so that more of the total potential drop appears across the vertical portion, causing the electrons to be accelerated more rapidly.

It is suggested that a process of this type might account for the auroral break-up phenomenon, and that the vertically accelerated electrons are the cause of the X-rays which have been reported as appearing when quiet arcs break up into active forms[4]. The display will continue until the voltage has been discharged.

It is interesting to note that during daytime, N is so much larger that this discharge would occur much more rapidly without the production of extra ionization, so that aurora would be expected to be a night-time phenomenon. The same reasoning might explain the summer minimum in auroral activity. To explain the equinoctial maximum, we must remember that there are, in fact, two 'circuits' in parallel, one in each hemisphere. During the northern winter, most of the discharge will occur through the more highly conducting southern ionosphere, and only near the equinoxes will the two conductivities become nearly equal. Another interesting consequence of this mechanism is that the detailed form which an auroral display takes might be expected to be dependent on the local ionospheric conditions existing before the display begins. This point could be fairly easily checked.

It must be said that the foregoing remarks in no way pretend to form a theory of aurora. They have been presented merely to direct attention to what may prove to be a useful line of thought. Many questions of auroral behaviour have been left unanswered, and it is hoped that a quantitative examination of the validity of the process, which is now under way, might provide some of the answers.

I am indebted to my colleagues at the Geophysical Institute, and especially to Dr. C. T. Elvey, for stimulating discussion of this material.

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Health Hazards from Powerful Radio Transmissions

For many years radio-frequency heating has been used under controlled conditions for medical purposes. It is clear that radiation from a powerful transmitter might also cause heating of body tissues, and this, if excessive, would be harmful. While precautions have always been necessary to prevent this, the problem has recently become more important, since the powers and aerials now used are such that levels of field-strength considered to be dangerous can occur at some distance from the transmitter. In fact, this may be an important consideration in siting powerful transmitters.

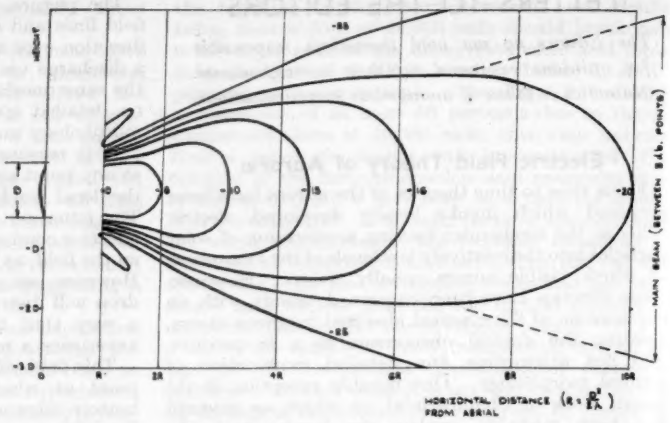

Fig. 1. Field-strength contours (in decibels) due to paraboloid of diameter D in free space

The level of field-strength which is dangerous was discussed by Schwan and Li[1]. They state that the maximum steady flux tolerated by the body is 30 mW./cm.^{2} for frequencies less than 500 Mc./s., 10 mW./cm.^{2} for frequencies between 1,000 Mc./s. and 3,000 Mc./s., and 20 mW./cm.^{2} for higher frequencies; for short exposures a much greater flux can be tolerated, for example, 300 mW./cm.^{2} for 1 min. It is of interest to predict, for particular powers and aerials, the positions at which the field will exceed the critical value.

Consider a simple aerial, a paraboloid fed by a horn; and assume that the gain of the horn is 8 db. (relative to an isotropic radiator), and the field at the edge of the reflector is 10 db. less than the field at the centre. The field outside the reflector will be less than this. It follows that, except in the region between the horn and the reflector, the direct field from the horn can be taken to be less than it would be if the horn were an isotropic radiator. This enables us to specify a 'danger distance' from the horn, for example, 3 m. for a horn radiating 10 kW. It is clear, therefore, that the danger area due to direct radiation from the feed is small.

This does not apply to the danger area due to the main field of the aerial. Fig. 1 shows the rough shape of the main field at distances between R and $10R$ from the aerial, where R is the 'Rayleigh distance', $D^2/2\lambda$, D being the diameter of the aerial. The contours are drawn relative to the 'maximum power flux'. This is taken to be the power flux on the axis at the Rayleigh distance. It is approximately equal to $2{\cdot}3P/D^2$, where P is the power. The power flux will in fact exceed this by up to $3\frac{1}{2}$ db. at some positions within the Rayleigh distance[2].

If P is 20 kW., D is 10 m., and λ is 35 cm. (reasonable parameters for a tropospheric scatter system), then the maximum power flux is 46 mW./cm.^{2}, and R is 141 m. If we add a factor of safety of 4 to Schwan and Li's figure of 10 mW./cm.^{2}, then the safe contour is 13 db. less. If the mean height of the aerial is 10 m. above the ground and the ground is level, then the whole of the ground between 270 m. and 620 m. (say half a mile) in front of the aerial is within the danger zone, since the flux exceeds the safe flux at heights below 2 m. This would normally by unsatisfactory. It can be remedied either by increasing the mean height of the aerial to 14 m.

or by tilting the aerial upwards by 0·45°, that is, about one-fifth of a beam-width. Such an aerial could therefore safely be placed on a cliff overlooking the sea, or with ground sloping away in front of it at an angle exceeding 0·45°.

The field at distances from the aerial less than the Rayleigh distance is largely confined within a cylinder the base of which is the reflector. The field below this cylinder is generally about the same as it is at the same height at the Rayleigh distance[2]. For example, for the aerial considered above (10-m. reflector, mean height 10 m., wave-length 35 cm.) the field at a height of 2 m. above the ground varies as one moves away from the aerial but is always more than 20 db. less than the 'maximum power flux' up to a distance of 200 m.; as one moves farther away, it increases to about 10 db. at 340 m., and then decreases continuously, reaching 14 db. at 680 m. and 20 db. at 1,380 m.

It is worth pointing out that the fields computed are those in free space. The ground will reflect radiation, the reflexion coefficient being dependent on wave-length, polarization, and the dielectric constant and roughness of the ground[3]. If the reflexion coefficient is −1 (horizontal polarization, smooth earth), then the field-strength at some points will be 6 db. greater than that in free space. This would account completely for the 'factor of safety' of 4 taken into account above.

An ionospheric scatter system on, say, 40 Mc./s., would not in general have such a large danger area, since the maximum power flux would be smaller and the allowable power flux would be greater. Radar systems will also have a smaller maximum power flux, and so are unlikely to be dangerous except near the axis of the beam. Even right in the beam, there will be no danger provided that the aerial is kept scanning. It might be worth while to point out that medium powers and small aerials can be dangerous; for example, 100 watts and 1 metre diameter gives a maximum flux of 23 mW./cm.², well above the tolerable limit; the Rayleigh distance is, however, quite small, being only 5 m. for a wave-length of 10 cm.

All these conclusions are subject to review in the light of new biological findings. The work of Schwan and Li[1] seems rather conjectural, but is the only solid basis available at present, apart from serious effects caused by much higher power densities[4]. It is clear that the adequate application of safety precautions would be much facilitated by a simple instrument which indicates whether or not a field of, say, 2 mW./cm.² is being exceeded. It is also of importance for pulse radar to know whether a strong field, say, 3 kV./m., lasting for a microsecond or so, can do any harm to the body apart from its heating effect.

I am indebted to the Engineer-in-Chief, Marconi's Wireless Telegraph Co., Ltd., for permission to publish this communication.

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Bismuth–Tellurium Photo-voltaic *p–n* 'Sandwich' Layer

It has been fairly well established[1,2] that bismuth telluride changes conductivity type[1,2] with the excess of tellurium over stoichiometric proportion between 1 and 2 atomic per cent[2]. It has been assumed that each excess Bi(Te) atom replacing the Te(Bi) atom in the single crystal of Bi_2Te_3 behaves as an ionized acceptor (donor)[1–3].

It seemed to me that if the conductivity type of a layer of semiconductor, approximately 1μ thick, evaporated on to the surface of a plate of insulating material would change from *p* (or *n*) to *n* (or *p*) in the direction perpendicular to the plate surface, it would possess the photo-voltaic property. An attempt to process such a layer was successful. I then reasoned in the reverse direction. Both the fact that the layer has shown the photo-voltaic property and the method of its preparation have suggested that the layer is of a 'sandwich', *p–n* barrier type.

A layer of bismuth was evaporated *in vacuo* on to the surface of a glass plate 8 cm. × 2 cm., covering little more than half of its length. Then a layer of tellurium was evaporated on to the uncovered portion of the plate overlapping the end section of the bismuth film in the middle area of the plate. Thus, the central portion was a 'sandwich' type Bi–Te layer of the area of ¼ cm. × 2 cm., while the remaining bismuth and tellurium portions served as leads which enabled the connexion of the 'sandwich' layer in series with a galvanometer and eventually with a battery.

The layer was then heated *in vacuo* up to a temperature of about 150–200° C. for a few minutes. After removing it from the evaporator, the layer showed the following properties in atmospheric air. Its dark resistance was about 7,000 ohms at room temperature. Under an intensity of illumination of 25×10^{-5} lumens/mm.² given by a tungsten lamp it decreased by about 15–20 per cent. The photo e.m.f. generated by the same radiation intensity amounted to about 50 millivolts. The bismuth electrode acquired positive potential on illumination in respect to the tellurium electrode. The response time was of the order of a few msec., proving the effect to be photo-electric.

Tentatively, these effects could be accounted for in the following way. As soon as crystallites of bismuth in the 'sandwich' portion of the layer come in contact with those of tellurium, diffusion of the tellurium (bismuth) atoms, enhanced by elevated temperature, into the bismuth (tellurium) crystallites occurs. It is presumed that one, or both, of two things may then happen: either tellurium (bismuth) crystallites with bismuth (tellurium) wrong site atoms, acting as acceptors (donors), or bismuth (tellurium) rich bismuth telluride (Bi_2Te_3) crystallites are formed, in the latter case with (0001) planes parallel to the glass plate surface.

In both cases *p–n* barriers would be formed, with the *p*-type material on the side of the bismuth electrode, and the *n*-type material on the side of the tellurium electrode. Electron (hole) type conductivity in the planes parallel to the surface of the plate glass may also occur in the bismuth (tellurium) portion of the sandwich layer. Photo-conductive layers of Bi_2Te_3 have been made by other investigators[4–5], but no details have been revealed.

The above method could perhaps be applied to other compounds characterized by low temperature

of dissociation and considerable difference in the boiling temperatures of the elements (constituting elements belonging to groups occurring near each other in the periodic table of elements—narrow forbidden bands). To such compounds the 'evaporation method' applicable to compounds such as PbSe, PbTe, CdS[6,7] which do not dissociate during the evaporation (constituting elements belonging to groups occurring far from each other—wide forbidden bands) cannot be applied.

The method described seems to be promising in processing layers consisting of elements which obey the (8–*N*) rule in forming single crystals, and the behaviour of which can be explained in terms of Brillouin zones.

I am indebted to Prof. D. C. White, Prof. J. F. Reintjes and Dr. J. W. McArthur of the Servomechanism Laboratory of the Massachusetts Institute of Technology for making available to me the facilities of the Laboratory.

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Evidence of Lattice Defects preceding Oriented Transformations during the Heat Treatment of Kaolinite

Recently, Brindley and Nakahira[1] have expressed their belief in the existence of a defect silicon-spinel phase preceding the transformation into mullite of kaolinite. This view has also been endorsed by Steadman and Youell[2]. Brindley and Nakahira[1] have obtained evidence that the spinel phase has a high degree of orientation with respect to the original kaolinite crystal. Oriented transformations of this type have been observed by Bernal *et al.*[3] and by Steadman and Youell[2]. It may be mentioned here that I also observed oriented transformation of kaolinite into mullite during its heat treatment, the (002) plane of kaolinite being converted into the (231) plane of mullite[4]. The aim of this communication is to present experimental evidence for the existence of disordered phases preceding the formation of mullite during the heat treatment of kaolinite.

A sample of kaolinite from Singhbhum, India, was tested by the differential thermal analysis method. This resulted in two prominent endothermal peaks at 140° C. and 550° C. each and a prominent exothermal peak at 1,000° C. This is in conformity with the observations of Spiel, Berkelheimer, Pask and Davies[5]; Ross and Kerr[6]; and Grim and Bradley[7]; and showed that dehydration started at 140° C., was almost completed at 550° C. and a new phase, the mullite, appeared at 1,000° C. X-ray diffraction powder photographs of kaolinite were taken after its heat treatment to 510° C., 692° C. and 930° C., that is just before and after dehydration of kaolinite was mostly complete and during the formation of Brindley's spinel phase. The line profiles of the various reflexions were studied with the help of a Hilger non-recording microphotometer. From the observed line profiles the effects of particle-size broadening were eliminated, and the pure diffraction line profiles were recovered by applying the method due to Stokes. It is observed that pure diffraction line profiles of reflexions corresponding to the (002), (113), (131), (060), (331), (106) and (033) planes of kaolinite are asymmetrical and that the asymmetry of the curves increase with temperature. This means, according to Hendricks and Teller[8] and Wilson[9], that there are defects in the interlayer distances in those directions and that the disorder increases with temperature. Now these are the planes which ultimately[4] become converted into the (231), (422), (822), (0,12,0) and (444) planes of mullite. (Indexing of the mullite planes has been carried out according to the lattice parameters proposed by Gillery[10].) Thus it becomes apparent that the oriented transformation of kaolinite into mullite is preceded by lattice disorders which increase with temperature until the formation of the new phase starts.

A detailed account of the work will be published shortly.

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A Method of studying the Variation with Temperature of Ultrasonic Absorption in Liquids

The study of the temperature coefficient of ultrasonic absorption in liquids is of fundamental importance for an understanding of the particular molecular mechanism responsible for the phenomena observed. The dependence of absorption in liquids on temperature has been studied by a number of workers by taking measurements of absorption at different temperatures by the pulse method[1] and by the interferometer method[2].

The present communication describes a simple method of measuring the temperature coefficient of absorption using a fixed-path double crystal interferometer with the liquid under study enclosed between identical sender and receiving crystals. The sender crystal is excited at its fundamental by the radio-frequency voltage output from a crystal oscillator and power amplifier, and the voltage across the receiving crystal is measured by a sensitive valve voltmeter. As the liquid in the ultrasonic cell is heated gradually the deflexion in the valve voltmeter is found to change continuously, giving sharp maxima at those temperatures at which a stationary wave is

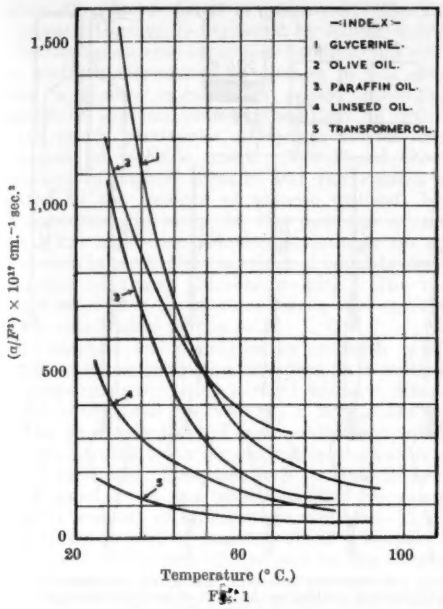

Fig. 1

formed in the liquid column. Following the treatment of Musa[3], it can easily be shown that these maxima occur at those temperatures satisfying the relation:

$$L = (2n + 1)\lambda/4 \qquad (1)$$

where L is the length of the liquid column and λ is the wave-length of the ultrasonic wave. The expression for the voltage V across the receiving crystal can be written in the form:

$$V_m = K/\sinh(\alpha L + \beta) \qquad (2)$$

where α is absorption per unit length and K is a constant. For highly viscous liquids, the value of the parameter β can be safely assumed to be small compared with αL, so that it can be neglected. Equation (2) can easily be utilized for the calculation of α at various temperatures provided K is evaluated by assuming a known value of α at one temperature determined by a standard method. By measuring the voltages across the receiving crystal at various temperatures at which maxima are observed and using equation (2) the absorption coefficient α is calculated at several temperatures and a graph can be drawn showing the variation of α with temperature. The method has been applied to some common viscous liquids and the results are shown in Fig. 1. The results for olive oil, glycerine and linseed oil are in good agreement with those of Verma[4] and Hunter[5]. It will be noticed that in almost all these oils the absorption coefficient falls off rapidly in a more or less exponential manner with increase of temperature.

The method has the advantage that there are no movable parts, and the equipment is quite simple. The accuracy of the determination of the variation of α, which is entirely dependent on the indicating voltmeter and the device measuring temperature, is found to be better than 5 per cent. The absolute accuracy of α depends on the accuracy of the value of α assumed or measured at one temperature. The method has the advantage that, with the same apparatus, the temperature coefficients of both ultrasonic velocity and absorption can be determined simultaneously using the same set of readings. It has been possible at present to apply this method only for the study of temperature effect on absorption in highly absorbing liquids having large temperature coefficients. However, the method can readily be modified for application to other liquids.

We wish to thank the Council of Scientific and Industrial Research for financial assistance for this project.

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Diffraction of Light by Ultrasonic Waves, Oblique Incidence and Sound Intensity

The experimental results reported in a previous communication[1] confirm the existence of several maxima for the second- and the third-order diffraction lines at oblique incidence and at low sound intensities, when the sound wave-length is small as expected by the closed intensity expressions of Aggarwal[2]. We have now observed for this small sound wave-length that, when the sound intensity is slowly increased, the number of these maxima diminishes. Further, the emphasis appears to shift towards the first Bragg angle, instead of the diffraction order attaining the maximum intensity at its respective Bragg reflexion angle. The secondary maxima for the second- and third-order diffraction lines at the Bragg angles corresponding to the higher orders slowly disappear, until the maximum intensity occurs only at the Bragg angle corresponding to the first order.

The experimental procedure was the same as that described earlier. Fig. 1 gives the results for the second order of the diffraction pattern on one side in terms of the Bragg angle at three different sound intensities. Here $\alpha/2$ is the reflexion maximum for the first order.

The graph shows that the second order attains three peaks at $\alpha/2$, α and $3\alpha/2$ at the lowest sound intensity (radio-frequency volts on the crystal: 22) which diminish to two at $\alpha/2$ and α with the increase in the sound intensity (radio-frequency volts: 54)

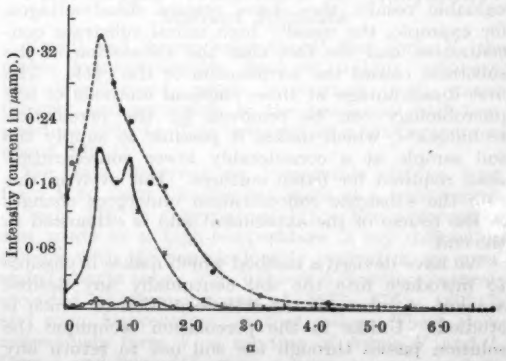

Fig. 1. Radio-frequency voltage: ○, 22 V.; ×, 54 V.; ⊙, 86 V.

and to only one at $\alpha/2$ with the further increase in the sound intensity (radio-frequency volts: 86). The pattern for the third order, which is not reproduced here, follows a similar trend; while that for the first order attained only one maximum at $\alpha/2$ irrespective of the sound intensity.

This phenomenon observed by us cannot be explained completely by any of the existing theories[3]. Aggarwal's closed intensity expressions become less accurate at higher sound intensities. However, from the series solution extended by Aggarwal[2], one sees that the variation in the intensity of a particular order is more pronounced for lower sound intensity. Thus the peaks decrease in number with the increase in the sound intensity. The results can only be qualitatively visualized on the basis of multiple diffraction. When the diffraction pattern contains many orders, the intensity of the lower order lines is the resultant of the contribution and redistribution from and to the lower as well as higher orders, while the contribution to the intensity of the highest order comes only from the lower orders. Therefore the variation in the intensity of a particular order will be more pronounced only when that particular order is the highest order in the pattern, or in other words, when the sound intensity is low.

The results can be explained mathematically only if one is able to obtain closed intensity expressions by considering the situation that all the orders exist simultaneously. Because of the mathematical difficulties in obtaining such a solution, a physical conception only is suggested at this stage.

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Continuous-Flow Method for the Study of Microbiological Processes in Soil Samples

The existing means of studying microbiological processes in soil samples are derived from the classical methods of microbiological cultivation. They are based on the principle of a single enrichment of the soil with the appropriate substrate. The processes occurring there can be expressed by a curve characteristic of microbiological processes in closed systems. Even if these methods have produced some valuable results they have certain disadvantages, for example, the usually high initial substrate concentration and the fact that the exhaustion of the substrate causes the termination of the cycle. The first disadvantage of these classical methods of soil microbiology can be removed by the percolation technique[1,2], which makes it possible to supply the soil sample at a considerably lower concentration than required for batch cultures. But even in this case the substrate concentration undergoes changes in the course of the experiment and is exhausted in the end.

We have devised a method which makes it possible to introduce into the soil continually any desired amount of substrate the transformation of which is studied. Unlike in the percolation technique the solution passes through the soil not to return any more into circulation. It is basically an application

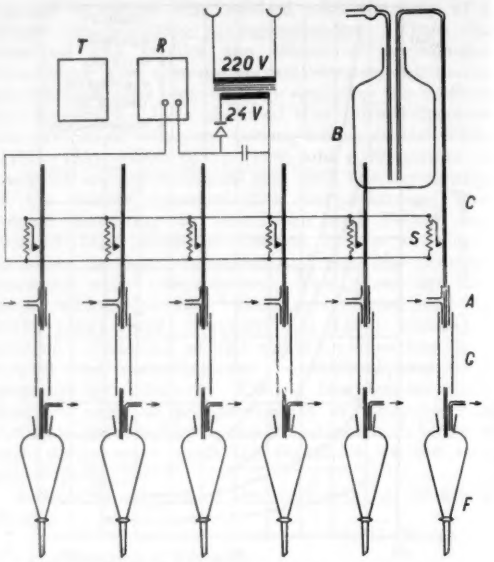

Fig. 1. A schematic representation of the apparatus for the continuous-flow method for the study of microbiological processes in soil samples

of the continuous-flow method of culture of microorganisms to the study of microbiological processes in the soil[3–6].

We have used an apparatus (Fig. 1) consisting of six cultivation units and a feeding mechanism. The stock solution inflow is regulated by electromagnetic screws[7] S, closing the rubber tubing through which the liquid passes from the stock bottle B to the growth tube G. The screws are controlled by a time switch T and by a slow-down relay R, which makes it possible to change the period of opened tubing between 0·5 and 2 sec.; the intervals between the individual impulses causing the screw to be released can vary between 15 sec. and 5 min. This mechanism ensures a constant flow and permits regulation of its rate. Capillary tubing C included in the circuit increases the regularity of amount of liquid passed in.

The cultivation unit is fundamentally identical with the percolation apparatus described by Audus[8] adapted for continuous flow. The soil sample is placed in a glass tube G closed at both ends with rubber stoppers. At the upper end of the cultivation tube the rubber stopper holds a wider glass tube with a side-arm A for passing in air and with a thin glass or capillary tube for passing in the nutrient medium which is connected with the stock bottle. After passing through the soil, the solution is collected in a separation funnel F. The stopper closing the separation funnel is provided with three holes, for the connecting tube from the cultivation flask, for an outlet to the pump and for a tube with a stopcock filled with an absorbent for the absorption of carbon dioxide; it serves also for passing air into the separation funnel when the collected solution is being removed.

The passage of the solution and the aeration of the soil are ensured by a constant suction similar to that in Audus's apparatus[8]. The introduced air is purified by removing carbon dioxide, and after passing through the soil it is introduced into the absorption flask with alkali; there the amount of

carbon dioxide produced is estimated. The rate of air passing through is regulated by needle valves.

We have used this apparatus for studying nitrification and transformation of glucose in soil samples. When a glucose solution is passed through, the decrease in glucose concentration can be estimated as well as the production of carbon dioxide and the formation of volatile acids. We found that the formation of carbon dioxide and the volatile acids (related to the amount of glucose utilized) by the soil microflora is lower in the presence of nitrate than when a glucose solution containing no source of nitrogen is used. Only acetic acid could be detected by means of paper chromatography. The results show that under certain conditions an equilibrium state is established in the soil.

The method has principles in common with the method of heterogeneous continuous-flow cultivation of micro-organisms using a solid carrier. Similarly, as with continuous cultivations, it is possible also in our case to supply the soil continually with substrate at a considerably lower concentration than with other current methods. However, it is possible to prevent the exhaustion of the substrate and to ensure a sufficient amount of nutrients in the soil. Thus the soil population can be maintained at a certain level determined by the rate of flow and by the concentration of essential nutrients. As the controlling growth factor, an energy source, a nitrogen source and the like can function. It is also possible to follow the transformation of various substrates one after the other and to influence the composition of the soil microbial association.

Detailed results are to be published elsewhere.

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Thermal Annealing of Chemical Radiation Damage

At present the only observations on the thermal annealing of chemical radiation damage appear to be some measurements on potassium nitrate reported in 1955 [1]. These measurements did not include isothermal kinetic studies, nor do they appear to exclude some possible alternative explanations of the observations. We have made measurements on the isothermal annealing of radiolysed lead nitrate and subsidiary experiments which seem to exclude any alternative explanation of the results. The experiments were conducted on a sample of vacuum-dried lead nitrate crystals sieved to between 80 and 100 mesh. The crystals were irradiated to a dose of about 50 Mr. with 2 MeV. electrons from a Van de Graaff accelerator. A typical plot of the disappearance of the nitrite, produced by the irradiation, upon thermal annealing of the crystals is shown in Fig. 1.

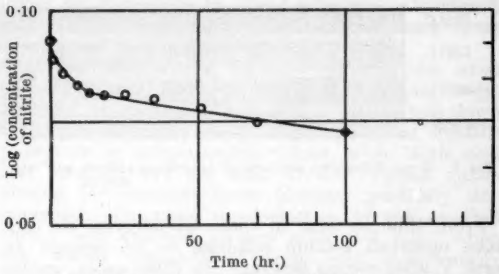

Fig. 1. Thermal annealing of irradiated lead nitrate

The possibility that the observed effect arose from aerial oxidation was excluded by showing that virtually the same annealing occurred whether the crystals were heated in air or *in vacuo*. Another possibility that the disappearance of the nitrite was due to thermal decomposition of the lead nitrite, to give lead oxide and oxides of nitrogen, was excluded by showing that in synthetic mixed crystals of lead nitrate and nitrite, prepared by crystallization from a solution of the nitrate and nitrite, the concentration of nitrite was unchanged after heating for 65 hr. at 150° C. *in vacuo*. It is concluded that the effects observed represent a true annealing of the chemical radiation damage. Similar experiments have shown that photolysed lead nitrate crystals can be annealed in the same way.

Such an effect is implied by the model for the radiolysis recently proposed by Cunningham and Heal[3], but the kinetic pattern of the recombination is more complex than the unimolecular recombination indicated by this model. A detailed account of the results and an analysis of the kinetic aspects will appear shortly.

We are indebted to Tube Investments Research Laboratory, Hinxton Hall, Cambridge, for carrying out the irradiations.

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Polymorphic Transitions in Anhydrous Sodium Sulphate

Kreidl and Simon have noted[1] that form V, the stable low-temperature form of sodium sulphate, was transformed, when in contact with water, directly and reversibly to the hexagonal high-temperature form I. This occurred at a temperature of about 238° C.

We have observed an irreversible change from form V to form I in the dry state at a temperature of only 176° C. (approximately). The observation was made in a high-temperature X-ray diffraction camera with the sample loosely packed in an open-ended quartz tube. Fig. 1 shows diffraction patterns recorded at temperatures of 161°, 176°, 180° C., and room temperature, in that order. These show respectively form V, a mixture of forms V and I, form I and form III.

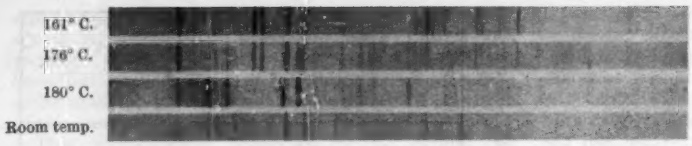

Fig. 1. X-ray diffraction patterns of anhydrous sodium sulphate. Sequence obtained during heating and cooling

From time to time in these laboratories we also have observed sodium sulphate to be present as form V after strong heating. In these cases, unlike Kreidl and Simon's experiment, cooling was not rapid nor was water likely to be present. We have not yet investigated the factors responsible for this change, which is contrary to the hitherto accepted behaviour of sodium sulphate.

I wish to thank the Directors of "Shell" Research, Ltd., for permission to publish this communication.

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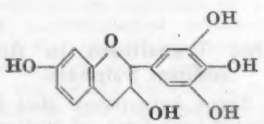
Black Wattle Catechin

Condensed tannins present in black wattle or commercial 'mimosa' extracts from the bark of *Acacia mollissima* show absorption behaviour ($\lambda_{max.}$ = 203 and 280 mμ) in the ultra-violet spectrum[1], which is typical of the natural catechins and flavan-3.4-diols[2] and also of their constituent phenols. Furthermore, the degradation products resulting from the fusion of the tannins with alkali under anhydrous conditions (mainly resorcinol and gallic acid, but also phloroglucinol and protocatechuic acid), and from alkaline permanganate oxidation of the methylated tannins, resemble those degradation products usually obtained by similar methods from flavans[3]. On such evidence and by analogy with Freudenberg and Maitland's[4] earlier concept of 'quebracho catechin', one of us previously[5] regarded the catechin structure, 3.7.3′.4′.5′-pentahydroxyflavan (I), as a possible prototype of many of the complex tannins present in black wattle extract.



(I)

Recently, by means of methods outlined by one of us[6], constituents *G*, *H* and A_2 of wattle tannins[6] have been isolated in pure crystalline form and shown to be catechins. These rank among some of the major catechin components of the extract.

Constituent *H*, $C_{14}H_{18}O_8$, melting point 205–7° C., $[\alpha]_D^{20} = +10{\cdot}7°$, $\lambda_{max.}$ = 203 and 281 mμ, gives colour reactions and degradation products indicative of the presence of resorcinol and pyrogallol nuclei only. Assuming the substance to be a flavan, the probable presence of five hydroxyl groups could be deduced from its chromatographic behaviour. Methylation with diazomethane afforded an O-tetramethyl derivative, melting point 140–1° C., $[\alpha]_D^{20} = -21{\cdot}6°$, showing that four hydroxyl groups are phenolic. The remaining aliphatic hydroxyl could be acetylated affording a mono-acetyl tetramethoxyl derivative, melting point 73° C.

These constants are in excellent agreement with those obtained by Weinges[7] for (−)-robinetinidol of structure I (and its corresponding derivatives), which was isolated from the hydrogenation of (+)-7.3′.4′.5′-tetrahydroxyflavan-3.4-diol (*leuco*-robinetinidin). This (−)-robinetinidol and constituent *H* from black wattle tannins show identical infra-red absorption curves over the range 2·5–15μ, and migrate to identical positions on paper chromatograms in three different and selective solvent systems. Mixed melting points of the corresponding derivatives show no depression. The presence of an *epi*-modification (2.3-*cis* substituents) of robinetinidol in wattle extract is also suspected from chromatographic evidence.

This, therefore, represents the first recorded isolation of a catechin (flavan-3-ol) of the resorcinol series from natural sources. The isolation of (−)-robinetinidol (2.3-*trans* substituents) also suggests that (+)-robinetinidol might occur naturally, as recently found for the enantiomorphous pair (+)- and (−)-7.3′.4′-trihydroxyflavan-*cis*-3.4-diol[8], and in apparent contrast with the phloroglucinol series of catechins, for example, gallocatechin, catechin and afzelichin, where mainly (−)-*epi*- and (+)-forms occur in plants.

Constituents *G* and A_2 of wattle extract were previously identified as (+)-catechin and (+)-gallocatechin respectively by means of paper chromatography by one of us[9]. This tentative identification is confirmed by their isolation and comparison with the same compounds obtained from *Casuarina equisetifolia*[10].

Our sincere thanks are due to Dr. K. Weinges, and to Prof. Karl Freudenberg, of the Chemical Institute, University of Heidelberg, for advance information regarding (−)-robinetinidol and also for specimens of the synthetic compound and its derivatives; also to Dr. J. R. Nunn, of the National Chemical Research Laboratories, Council for Scientific and Industrial Research, Pretoria, for kindly performing the infra-red comparisons.

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Evidence for a Relation between Creatine Phosphate Level and Polarity of the Cerebral Cortex

THE surface of the cerebral cortex in rats is 15–20 mV. positive against other electrically indifferent sites[1,2]. This steady potential can serve as an indicator of brain survival[3,4].

In the present study we attempted to characterize metabolic processes that might participate in maintaining normal cortical polarity. For this purpose the levels of some metabolites were determined in the rat brain during the various phases of steady potential changes caused by transitory brain ischæmia and following resuscitation. Rats anæsthetized with 'Dial' were used throughout. The polarity of the cerebral cortex was measured between an area damaged by thermocoagulation and the normal cortical surface using a chopper direct-current amplifier and cathode ray oscillograph. Ischæmia was induced by a modification of the method of Opitz and Thorn[5]. After exposing the trachea, the neck of the rat is compressed by a rubber band. Although some blood still goes to the head through the spinal and vertebral arteries under these conditions, there is a characteristic decrease in cortical polarity with a half-time roughly equal to that after decapitation. From the time of compression artificial respiration was applied through the free trachea so that cardiac activity remained normal. After 10 or 20 min. the rubber band was released and the return of polarity observed. In various phases of repolarization animals were killed by immersion in liquid nitrogen. Glycogen[6], glucose[7], lactic acid[8] and creatine phosphate[9] were determined in the hemispheres.

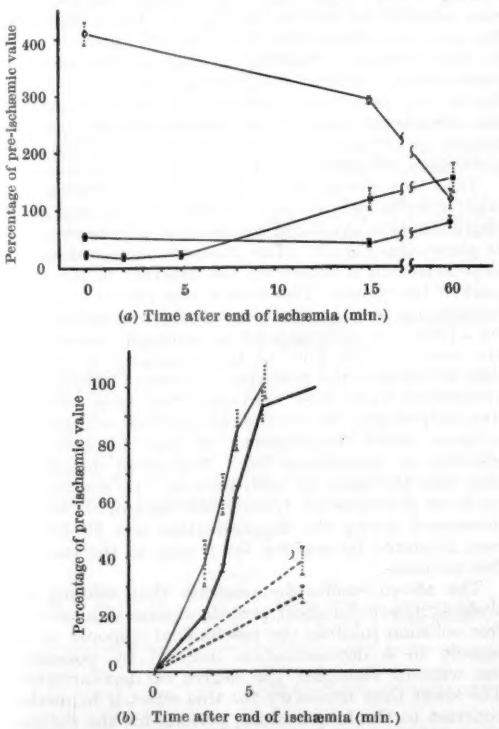

Fig. 1. Changes of (*a*) glycogen (●—●), glucose (■—■), lactic acid (○—○) and (*b*) creatine phosphate (thin line) and cortical polarity (thick line) after 10 min. (full lines) or 20 min. (interrupted lines) ischæmia. Vertical dotted lines indicate standard error of the mean

At the end of the 10 min. of ischæmia, when cortical polarity had disappeared almost completely, glycogen, in agreement with the literature, was down to 52 per cent, glucose to 26 per cent and creatine phosphate to unmeasurable values, while lactic acid had risen to 411 per cent of the original value. During resuscitation these changes gradually disappeared. Complete repolarization of the cerebral cortex was attained already after 8–9 min., when the above metabolites were still considerably decreased (Fig. 1*a*). Statistical analysis of 75 correlated pairs of values for repolarization and creatine phosphate-levels shows a close correlation ($r = 0{\cdot}61 \pm 0{\cdot}07$). Renewal of the original creatine phosphate-level precedes that of cortical polarity by a fraction of a minute (Fig. 1*b*). From the above and from what is known about cerebral cortical metabolism it seems reasonable to assume that a causal relationship exists between the level of creatine phosphate and cortical polarity. Experiments with 20-min. ischæmia show that this correlation is not accidental. Repolarization under such conditions is much slower, but the correlation between the cortical steady potential and creatine phosphate-level remains unchanged.

The inability of other authors[10–13] to find a direct relation between creatine phosphate or adenosine triphosphate decrease and disappearance of spontaneous electroencephalogram activity or evoked potentials during anoxia or ischæmia, may be explained by the fact that these forms of cerebral activity are due to synaptic organization of neurones and the corresponding specific metabolism of brain mediators. The cortical steady potential, on the other hand, is a result of potential differences between various parts of the cell membrane of the cortical neurones sustained by active transport of ions. Renewal of polarity during resuscitation is not dependent, therefore, on a return of glycogen, lactic acid and glucose to normal levels, but rather on a restoration of creatine phosphate, or possibly of other high-energy phosphates serving as a direct source of energy for active transport through the cell membranes.

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Inward Movement of Calcium as a Link between Electrical and Mechanical Events in Contraction

Although there is every indication that the electrical events at the surface of cardiac and skeletal muscle fibres lead to the activation of the myofibrils within, there is as yet little definitive evidence as to the nature of the process linking these two events. Evidence showing that it is the depolarization of the fibre surface which is the electrical event responsible[1] has led many authors to suggest that the depolarization permits or promotes the entrance of a substance which then initiates the contraction. In particular, calcium ions have frequently been suggested as the substance responsible[2]. The recent demonstration by Hodgkin and Keynes[3] that there is an influx of calcium ions with each action potential in the squid giant axon has encouraged me to investigate the above hypothesis.

If there is an inward movement of calcium playing the part suggested above, it should be possible to eliminate the mechanical response of a skeletal muscle to electrical stimulation by soaking the muscle in a solution free of calcium. However, since this procedure makes skeletal muscle electrically inexcitable[4], another method was used. This consisted of studying the effect of soaking a skeletal muscle in a calcium-free solution for various periods of time on the contracture induced by a solution containing 25 m*M* potassium. The complicating effects on electrical excitability produced by changes in the concentration of calcium ions were eliminated by replacing 98 per cent of the sodium in the solutions with choline. All solutions contained 10^{-4} gm./cm.^{3} *d*-tubocurarine (Burroughs-Wellcome). The extensor digitis longis IV muscle of the frog was used because its small size (0·2–0·5 mm. diameter) allows rapid equilibration.

Typical responses produced by the excess potassium ions under the conditions specified are shown in Fig. 1*a* and *c*. Also shown are responses of the same muscle after treatment with the calcium-free solution. All mechanical recordings were produced under highly isometric conditions. After each response the muscle was placed in a solution containing the normal concentrations of potassium and calcium ions

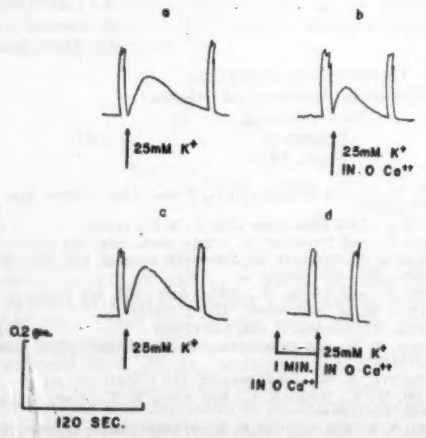

Fig. 1. Four successive contractures (*a*, *b*, *c*, *d*) produced during an experiment on a single muscle. *a* and *c* control responses. Large rectangular deflexions at start and end of contractures are artefacts produced by changing solutions in the bath

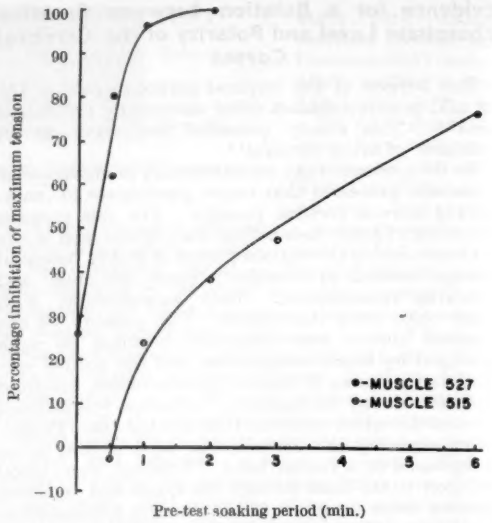

Fig. 2. Inhibition of the maximum isometric tension of the contracture induced by potassium ion due to pretreatment of the muscle with a calcium-free solution

for 10–15 min. before another response was elicited. Each test, using calcium-free solutions, was preceded and followed by a control test. In these muscles the control responses remained essentially unaltered during 4–5 hr. of testing. The results obtained with two muscles are shown in Fig. 2. These represent the extremes obtained in about twenty muscles tested in this manner. Soaking in calcium-free solutions consistently inhibited the response, and, if continued for as long as 12 min., always completely eliminated the contracture induced by potassium ion. Similar results are obtained if an isotonic solution (123 m*M*) of potassium chloride is used to induce the contracture.

That this change in the height of the contracture was independent of any change in the degree of depolarization produced by the excess potassium ion is shown in Fig. 3. The method of recording the depolarization is shown by the diagram in the lower part of the figure. The muscle was placed in a bath comprising two compartments which were isolated by a petroleum-jelly gap 8 mm. in length surrounding the muscle. The lines at the beginning of Fig. 3*A* and *B* indicate the potential difference between the two baths when they contained the same solution. The only change due to the calcium-free solution was a more rapid development of the depolarization induced by potassium ion. Maximum depolarization was the same in both records. In contrast, in most of the muscles tested, the maximum tension developed during the depolarization was 90–100 per cent inhibited by soaking for 5 min. in the calcium-free solution.

The above results demonstrate that soaking this skeletal muscle for short periods of time in a calcium-free solution inhibits the mechanical response of the muscle to a depolarization induced by potassium ion without changing the degree of depolarization. The short time necessary for this effect is in marked contrast to the long soaking periods for the removal of intracellular calcium[5], and strongly suggests that the effect is due to the removal of extracellular calcium. These results support the idea that there is an inward movement of calcium ions when the

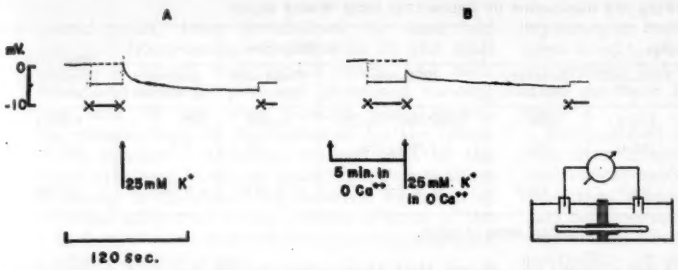

Fig. 3. Depolarizations produced by adding excess of potassium ions to the solution bathing a part of the muscle in one compartment of the bath. The recording instrument was turned off during the periods enclosed by the X marks (X—X) to permit the changing of the solution. The dashed lines are inked in continuations of the zero potential lines

muscle fibre is depolarized and that this calcium acts as a link between electrical and mechanical events in contraction.

In line with this work, Shanes and Bianchi have recently shown that there is an increased influx of calcium ions associated with action potentials and depolarizations induced by potassium ion in skeletal muscle (personal communication). Further details of this work, with evidence showing that the time course of this inhibition is determined by the rate at which calcium ions leave the extracellular space, will be published later elsewhere.

This work was supported by a grant from the National Research Council of Canada, to which I wish to express my thanks.

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Influence of Cysteamine on the Teratogenic Action of X-radiation

IT has been shown by Bacq and his collaborators[1] that the administration of cysteamine (β-mercaptoethylamine) is an extremely effective method of protecting adult animals against X-radiation. The present series of experiments were carried out in order to determine whether the administration of cysteamine to pregnant animals immediately prior to exposure to X-radiation had any value in the prevention of X-ray induced malformations in their young.

Table 1

Group	No. of dams	No. of young	Average weight of fœtus (gm.)	No. of young with meningocœle	No. of young with cleft palate
1 Radiation only	30	155	0·39	44 (38·4 per cent)	149 (96·1 per cent)
2 Radiation and cysteamine	27	163	0·59	4 (2·4 per cent)	144 (82·2 per cent)

Fifty-seven female mice of the Strong *A* line were used in these experiments. Only brother–sister matings were used throughout the experiment and the onset of pregnancy was determined by the presence of a vaginal plug, the day on which the plug was detected being taken as day 1 of the pregnancy. Two groups of animals were formed. Animals in both groups 1 and 2 received 300 r. whole-body radiation on day 12 of pregnancy. Animals in group 2 received in addition, by intraperitoneal injection, 4 mgm. of β-mercaptoethylamine hydrochloride dissolved in 1 ml. of physiological saline, 2–5 min. before the onset of exposure to X-radiation. On day 18 of pregnancy all the animals were killed. The young were removed from the uterus, weighed and examined for the presence of deformities.

Deformities encountered included syndactyly, micromelia, anophthalmia, hydrocephalus, meningocœle and cleft palate. The incidence of the last two malformations is shown in Table 1. There was a markedly lower incidence of all deformities with the exception of cleft palate in the group which received cysteamine (group 2).

From the findings of these experiments it is concluded that the administration of cysteamine to the pregnant animal considerably mitigates the deleterious effects of X-radiation on the developing fœtus. The significantly higher average fœtal weight in group 2 suggests a parallel with the observation of Bacq *et al.*[2] that cysteamine protects the adult animal against the fall in weight which follows exposure to high doses of X-radiation. On day 12 of pregnancy the sensitivity of the developing mouse palate to 300 r. X-radiation is at its height[3], whereas the sensitivity of the brain and skull has passed beyond the most acute phase. It is significant in this regard to note that the administration of cysteamine in the quantities used in these experiments was considerably more effective in reducing the incidence of meningocœle than that of cleft palate.

This work was supported by a grant from the Nuffield Foundation, which is gratefully acknowledged.

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Separation of Human Leucocytes from Blood

BECAUSE of the growing interest in the antigenic structure of human leucocytes, the need has arisen for a simple method of collecting pure suspensions of white cells, and for this reason the following method has been evolved.

Essentially, the technique comprises four stages. (1) The erythrocytes are encouraged to form rouleaux

Table 1. Showing the Separation of Leucocytes from Whole Blood

	Leucocytes				Erythrocytes			Leucocyte Erythrocyte ratio
	Volume (ml.)	Cells/mm.³	Total cells $\times 10^6$	Recovery (per cent)	Cells/mm.³	Total cells $\times 10^6$	Recovery (per cent)	
Whole blood	15	7,649±79*	115·4	100	5,600,000±79,700	84,000	100	0·0014
Supernatant (stage 1)	12	7,750±150	93·0	81	7,000±389	84	0·1	1·1
Sodium edetate suspension (stage 4)	5	4,562±342	22·8	19·8	<2·5	<0·0125	<0·000015	>1,800

* Standard error of mean.

by one of the published methods[1] and are allowed to sediment leaving the leucocytes in suspension. (2) The resulting suspension is placed as a shallow layer in a wide vessel to the bottom of which many of the leucocytes adhere. (3) The supernatant is discarded and the adherent cells washed free of erythrocytes with buffered saline. (4) The white cells are resuspended by gentle agitation in sodium edetate[2] ('Versene'; 'Sequestrene') dissolved in calcium- and magnesium-free buffer (solution *A* of Dulbecco and Vogt[3]).

Stage 1. Although we have used 'Dextraven' to sediment erythrocytes, it is probable that other methods would serve as well, provided that two considerations are borne in mind. First, the concentration of red cells must be reduced sufficiently to allow the leucocytes to become attached in stage 2 and, secondly, the concentration of white cells must be as high as possible. In practice, it has been found best to mix three volumes of blood treated with heparin with one volume of 6 per cent 'Dextraven' (Benger Laboratories, Ltd.) and to allow the mixture to stand in test-tubes for 1 hr. at room temperature. Suspensions obtained in this way contain 75–85 per cent of the leucocytes originally present with about an equal number of red cells. No advantage has been found in prolonging sedimentation or by sedimenting at other temperatures.

Stage 2. Much attention has been paid to the factors governing the attachment of leucocytes to surfaces. Although in early experiments white cells were allowed to adhere to glass which had been prepared for tissue culture, subsequent experience has shown that a greater proportion adhere to 'greasy' surfaces such as siliconed glass or 'vaspar' (equal parts of 'Vaseline' and paraffin wax). Provided that the latter surface is used, the proportion of leucocytes which adhere is unaffected by the concentration of plasma protein in the leucocyte suspension[4]. Using a layer only 2 mm. in depth we have found two factors to be of importance. First, the percentage of leucocytes that adhere to the surfaces during stage 2 varies directly with the concentration of those cells in the supernatant from stage 1. Secondly, the temperature is important because ten times as many intact cells were found at the end of stage 4 when leucocytes were allowed to become attached at 28° C. than when this step was carried out at 37° C. With the thin layers of fluid used, little advantage was noted when the period allowed for attachment was prolonged beyond 60 min.

Stage 3. The most important factor for obtaining leucocyte suspensions free from erythrocytes is thorough washing of the 'vaspar' surface; attached leucocytes seem able to withstand fairly vigorous shaking. In practice, three vigorous washes using each time at least the same volume of buffered saline as the original leucocyte suspension have been found to remove more than 99 per cent of the red cells. At this stage, examination of the adherent cells shows that these comprise 88 per cent polymorphonuclear cells, 6 per cent monocytes, 2 per cent eosinophils, 4 per cent small mononuclear cells thought to be degenerate polymorphonuclear cells and fewer than 0·1 per cent erythrocytes (Fig. 1). No lymphocytes were seen at this stage.

Stage 4. Virtually all the attached leucocytes may be removed from the 'vaspar' surface by gentle agitation with 1 : 10,000 sodium edetate for 15 min. at 37° C. Concentrations greater than this disrupt many of the cells, and lower concentrations fail to remove all the cells.

The technique at present used is as follows: A mixture of 3 parts of heparinized blood and one part of 6 per cent 'Dextraven' is placed in test-tubes and left at room temperature for 1 hr. Up to 20 ml. of the supernatant is then placed in a Roux bottle the sides of which have been coated with 'vaspar'. After leaving the bottle undisturbed on its side at 28° C. for an hour, the bottle is agitated and the fluid in it discarded. The adherent cells are thoroughly washed three times using 20 ml. buffer each time and 5 ml. 1 : 10,000 sodium edetate is run in and gently agitated for 15 min. at 37° C. The resulting suspension is then ready for use. The overall results of such a separation are given in Table 1, where it will be seen that about 20 per cent of the leucocytes originally present were recovered and the leucocyte–erythrocyte ratio rose from 0·0014 to more than 1,800; a purification of more than a millionfold.

Attempts have been made to assess the viability, the antigenicity and the purity of such white cell suspensions. Viability was assessed in three different ways. First, the proportion exhibiting dancing cytoplasmic granules[5] and the proportion thrusting

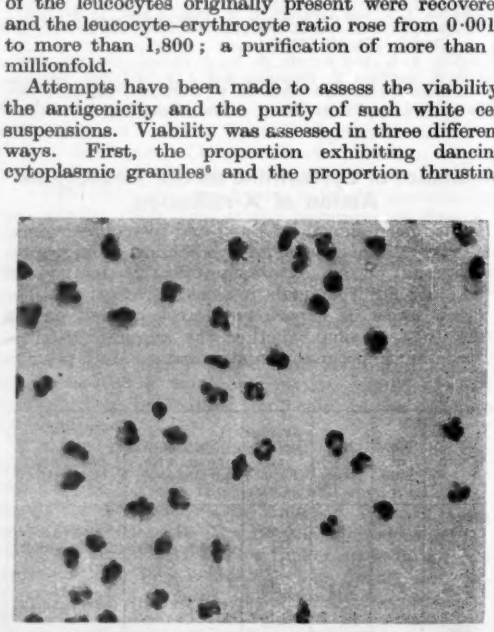

Fig. 1. Photomicrograph of a pure monolayer of leucocytes (stage 3). Leishman's stain. (× 280)

out pseudopodia, were determined by dark-field microscopy. Observation of 120 cells in the final suspension to which homologous serum had been added showed that 68 per cent possessed dancing granules and 64 per cent formed pseudopodia. Finally, phagocytosis of staphylococci by the leucocytes was studied. Although 80 per cent of the leucocytes appeared viable in these experiments there was difficulty in distinguishing between ingestion of the cocci and adherence to the surface of some of the cells. In fact, it seems possible that leucocytes remain sticky after viability is lost.

Antigenicity was shown by injecting a rabbit intravenously at weekly intervals with a million leucocytes/kgm. body-weight. It was found that serum taken ten days after the third injection and placed over a monolayer of leucocytes reduced the proportion of cells which exhibited dancing granules or formed pseudopodia. It also detached many cells from the glass and agglutinated them. None of these features was seen when serum taken from the same animal before immunization was used. White cell antibody was satisfactorily titrated by making a large number of replicate leucocyte monolayers of about a million cells each in slide cells (made by cementing 18-mm. stainless steel collars on to microscope slides with 'vaspar') and taking the separatory process up to the end of stage 3. Dilutions of serum were made in buffered saline, and 0·5 ml. of each was placed in a slide cell; these were incubated at 37° C. for 30 min. in a humid atmosphere. Each monolayer was then examined with a 2/3-in. objective. In control preparations the cells were still distributed as a monolayer attached to the glass while in immune serum detachment and agglutination were marked.

The method has the advantages that it is sensitive and simple to carry out, no human serum is present which might inhibit the antibody[1], the end-point is easy to determine and spontaneous clumping of cells does not interfere with the results. Using it we have found that serum taken before immunization had a titre less than 1 : 10, ten days after the third injection the titre was 1 : 1,280 and ten days after a further injection given at the sixth week the titre was 1 : 5,120. These three sera were titrated in parallel for red cell agglutinin by mixing the same dilutions with equal volumes of 2 per cent erythrocytes in buffered saline and reading microscopically after 30 min. The titres found were respectively $<1:10$, 1 : 20 and 1 : 160. Absorption of the last serum with erythrocytes reduced the red cell titre to less than 1 : 10 but left the white cell titre unaffected at 1 : 5,120. On the other hand, absorption with white cells reduced the white cell titre to 1 : 640 and the red cell titre to 1 : 40. These results suggest that this serum contained mostly white cell agglutinins and also antibodies specific for red cell and/or reacting with antigens shared by both cells[7]. Which of the last two possibilities were true might have been decided by mixed cell agglutination[8], but preliminary experiments have suggested that the phagocytic activity of leucocytes might give rise to mixed clumps of cells which would be mistaken for agglutinates.

It had been hoped to determine the purity of suspensions of white cells which were used as antigens by determining the nature of the antibodies produced. The preliminary studies mentioned above have failed to do this and the only criterion of purity that can be offered is that we have repeatedly obtained suspensions in which 2,000 to 3,000 leucocytes were consecutively counted without encountering a single erythrocyte and although they have not regularly been sought, platelets have not been found in final suspensions but have, on the contrary, been seen in large numbers in the suspension discarded during stage 3.

The method presented here of separating white cells from human blood combines a moderate yield with considerable purity and has the further advantages that spontaneous clumping does not occur and that cells remain viable and antigenic. Moreover, it may readily be adapted for titrating sera for leucocyte antibody. It is believed that the success of the method depends upon (*a*) avoidance of harsh procedures such as centrifuging and (*b*) the fact that the method selects only viable cells.

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Effect of Temperature on the Multiplication of Foot-and-Mouth Disease Virus in Suspensions of Kidney Cells of the Pig

RECENTLY, Lwoff and Lwoff[1] showed that the development of the virus of poliomyelitis in *KB* cell cultures (cell strain from a human epidermoid carcinoma—H. Eagle), while occurring 'normally' at 37° C., is at least partially blocked at 39° C., only about 0·2–0·4 per cent of the virus at 37° C. being produced. They found the blockage to be reversible and considered that it occurred in a "late stage of the vegetative phase".

No results of studies on the multiplication of the virus of foot-and-mouth disease growing in tissue culture at temperatures above 37° C. have been published. Cartwright, Pay and Henderson[2] recently published growth curves for 37° C.

In the present investigation this virus growing in pig kidney cells has been used exclusively. Pig kidney monolayers were prepared by Sellers's method[3]. Virus was titrated by the method of plaque counts[4], on pig kidney monolayers and also by 50 per cent end-point determination in baby mice inoculated intraperitoneally[5]; both methods giving similar results.

The virus strains used were pig kidney culture strains of either *M*.11 (Type *O*) or of *C* 997 (Type *C*).

Virus, usually not exceeding 0·4 plaque-forming units per cell, was placed on pig kidney monolayers. After 30 min. incubation at 37° C. the supernatant was removed and the cell sheet washed with saline buffered with phosphate and then treated with versene for 12–20 min. The resultant cell suspension was centrifuged at low speed, and after two washes in culture medium resuspended in this medium to give roughly 2×10^6 cells/ml. This suspension, after gassing with 5 per cent carbon dioxide in air, was incubated with continuous shaking in Carrel flasks

in water-baths thermostatically controlled with a maximum fluctuation-range of 0·25 deg. C. Strict control of temperature has so far not been possible during the 75-min. preparation preceding this stage.

For each test two samples were withdrawn. The first was immediately diluted 1 : 10 in saline buffered with phosphate and served for 'whole-culture' titration. Three components make up this 'whole-culture' titre: unadsorbed infectious virus; infected cells containing infectious virus not yet released into the supernatant; and infected cells containing no infectious virus, but potentially capable of forming it if incubated further (eclipse phase). The second sample was immediately centrifuged and the supernatant titrated. Any infectivity detected was due to unadsorbed infectious virus, though occasionally a few infected cells may also have contributed. The cell pellet was disintegrated by the addition of a 1 per cent solution of sodium dodecyl sulphate. This detergent does not affect the infectivity of the virus yet disrupts the cells in a matter of seconds[6]. Suitable dilutions of the sample treated with sodium dodecyl sulphate were then titrated. Any infectivity found must be due to infectious virus which is 'cell associated', that is, infectious virus attached to or in the cells at the moment of treatment with the detergent. In certain cases where unadsorbed virus was present in the supernatant, a trace of this virus could also be present in the sample. No contribution is made by the disrupted eclipse-phase cells.

Virus multiplication was studied at temperatures of 35·0, 37·1, 39·6, 41·1, 41·7, 42·1, 42·6, 43·6 and 45·0° C. The period during which the infective virus titre increased, and the total increase in titre, was approximately the same at 35·0, 37·1 and 39·6° C. (in the same experiments). With increasing temperature, while the period of increase in titre seemed to be of about the same duration, the total increase in titre fell off rapidly: at 41·1° only about 50 per cent of the total at 39·6°, at 41·7° 5–10 per cent, at 42·1° less than 0·5 per cent, and at 42·6° and 43·6° C. no infectious virus at all was detected (Table 1). Thus the amount of infectious virus formed was reduced at temperatures between 41° and 42° C. and complete blocking of successful virus multiplication occurred at temperatures above 42·6° C. At 45° C. the infected cells, though surviving for 45 min., had all disappeared 90 min. later.

Table 1. Virus Multiplication at Temperatures above 39·6° C. Results from three experiments titrated on pig kidney monolayers. Titres given to the nearest 0·1 $\log_{10}$ unit per 0·4 ml. of suspension

Time after absorption (min.)	Sample	Temperature (° C.)						
		39·6	41·1	42·6	43·6	41·7	42·1	45·0
75	*wc*	3·3	3·3	3·3	3·3	3·3	3·3	2·9*
	sds	<1·0	<1·0	<1·0	<1·0	<1·0	<1·0	<1·0
150	*wc*	3·3	2·9	3·2	3·1	2·8	2·3	2·2
	sds	<1·0	<1·0	<1·0	<1·0	<1·0	<1·0	<1·0
180	*wc*	3·7	3·2	3·2	3·0	3·0	3·0	
	sds	4·2	3·6	<1·0	<1·0	1·6	<1·0	
210	*wc*	4·4	3·9	2·8	3·0	3·3	2·6	
	sds	5·0	4·0	<1·0	<1·0	3·0	1·3	
240	*wc*							<1·0
	sds							<1·0
270	*wc*	5·0	4·4	2·3	2·7	3·3	2·7	
	sds	4·8	4·6	<1·0	<1·0	3·3	2·7	
330	*wc*	5·1	4·5	2·5	2·5	3·5	2·7	
	sds	4·8	4·0	<1·0	<1·0	3·0	—	

wc, Whole-culture sample; *sds*, sodium dodecyl sulphate-treated whole-culture sample.
* Transferred to 45·0° at 105 min.

As no infectivity was detected at any time in the samples treated with sodium dodecyl sulphate or in the supernatant at 42·6° and 43·6° C. (and also at all temperatures tested at 1½–2½ hr.) it follows that infectious virus amounted to less than 100 plaque-forming units (p.f.u.) per 4 ml. of suspension. Indeed, further experiments not included in the table showed that if infectious virus was present at all, it was less than 1 p.f.u. per 4 ml. Yet the same suspensions titrated as 'whole culture' contained more than 10,000 p.f.u. in the same volume. Thus comparisons of the curves for the 'whole-culture' with those for samples treated with the detergent (and with those for the supernatant) showed that at certain times in this system, and under these conditions of low multiplicity of original infection, all the detectable infectivity in a culture-sample resides in the *intact* cells which are presumed to contain virus in the eclipse phase; that is in such a state that it cannot be extracted as infectious virus by means shown to be capable of extracting such virus. All virus appears to enter the eclipse phase soon after infection. The eclipse phase at 39·6° C. ended between 160 and 170 min. when virus infectivity first appeared in the sample treated with sodium dodecyl sulphate.

The blocking of virus multiplication at 42·6° and 43·6° C. is reversible and affects a late stage in virus growth: a late stage because transfer of infected cells incubated at 39·6°–42·6° C. up to 150 min. after initial infection, that is, within 10–20 min. from the normal end of the eclipse phase, completely blocked the production of infectious virus. Reversibility was demonstrated by transfer of the virus cell system from 42·6°—39·6° C. after varying periods of incubation at 42·6° C. Such transfer results in the formation of infectious virus. However, the virus cell system seems to be altered, for although infectious virus was demonstrated within 30 min. of retransfer to 39·6° C., the period of increase in virus titre after such transfer was about three times longer than the corresponding 'normal' period at 39·6° C. Clearly, the temperature block altered the balance of the virus – cell system in such a way that its effects persisted at least for some considerable time after removal of the blocking effect. There is also some indication that on retransfer to 39·6°, after several hours incubation at 42·6° C., less virus is produced per infected surviving cell.

Infected cells could be held for at least 36 hr. in the eclipse phase by incubation at 42·6–43·6° C. It is of interest in this connexion that the death-rate of eclipse-phase cells at 42·6° C. is about 90 per cent in 8 hr., while that of free virus in the supernatant fluid (*p*H 7·6) is more than 99·9 per cent.

It should be stressed that what is reported here refers only to virus – cell systems in which the multiplicity of infection per cell was of a low order. It was found that initial infection with greater multiplicities of virus led to the detection of some cell-associated infectious virus throughout the normal eclipse phase and also for many hours of the temperature-prolonged eclipse phase.

These observations indicate that by the combined use of the temperature blocking effect on an appropriate virus – cell system and sodium dodecyl sulphate for extraction of infectious virus it should be possible to obtain further information on virus absorption and penetration and on succeeding stages of the multiplication process of the virus of foot-and-mouth disease.

I am indebted to Mr. R. W. Slade for technical assistance.

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Effects of Potassium and Sodium Ions on the Resting and Action Potentials of the Giant Axon of the Cockroach

A knowledge of the fundamental properties of the insect nerve is very useful in studying the mode of action of insecticides, many of which are nerve poisons. In order to verify the validity of the sodium theory[1] in the cockroach giant axon[2], the effects on the resting and action potentials of varying the sodium and potassium concentrations in the bathing fluid were examined with intracellular microelectrodes. A compensation circuit for improving high-frequency responses was employed in place of the simple cathode follower circuit used in our previous study[3]. The following mean values for the membrane potentials were obtained from axons immersed in modified Ringer's solution containing sodium ions at a concentration of 214 m*M*: resting potential 70·3 mV.; action potential 94·5 mV.; positive phase 3·4 mV.; maximum rate of rise of action potential 1,113 V./sec.; maximum rate of fall 382 V./sec.

Varying the external potassium concentration had a similar effect on the resting potential to that with other animals. Plotting the resting potentials against the logarithms of the external potassium concentrations resulted in a straight line in the higher concentration ranges. A decrease in the external sodium concentration had no appreciable effect on the resting potential, but it effectively depressed the action potential and eventually caused the axon to become inexcitable. The straight line for reversed potentials/log sodium concentrations diverged only slightly from the theoretically expected straight line having a slope of 59 mV. for a tenfold change in sodium concentration. Furthermore, when the axon came into contact with the solution deficient in sodium the rate of rise of the action potential was decreased more effectively than the rate of fall and the magnitude of the action potential. This behaviour of the cockroach axon in solutions of low sodium content is quite similar to that of the giant axon of the squid[4]. It can safely be said that the overall result constitutes strong evidence for the essential validity of the sodium theory in the giant axon of the cockroach.

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Synaptic Transmission in the Cockroach

Although the synaptic transmission across the last abdominal ganglion of the cockroach has been studied by several workers[1–3], the knowledge obtained so far seems to be less complete than for synapses in vertebrate animals. In the present investigation electrical phenomena associated with the synaptic transmission across this ganglion were analysed with special reference to the nature of the synaptic transmitter. The cercal nerve–nerve cord preparation was isolated[4], and postsynaptic responses were led off from the origin of the connectives from the last abdominal ganglion.

A presynaptic volley set up excitatory postsynaptic potentials. When these reached a certain critical level, propagated action potentials were generated. Excitatory postsynaptic potentials could be observed more easily by employing pharmacological agents such as urethane and phenobarbital. These substances depressed the discharge of impulses from the ganglion cells, keeping the potentials observable.

An application of anticholinesterases such as eserine, tetraethyl pyrophosphate and parathion caused a marked increase and prolongation of the excitatory postsynaptic potentials with a prolonged after-discharge superimposed (Fig. 1, *A* and *B*). The excitatory potentials grew so markedly that a persistent ganglionic depolarization associated with a synaptic block was eventually produced. Repolarization associated with a recovery of synaptic transmission occurred after some time. Alternate depolarization and repolarization might occur without presynaptic stimulation. By employing urethane or phenobarbital it was clearly demonstrated that the anticholinesterases caused the ganglion to give a very prolonged excitatory postsynaptic potential with no discharges superimposed (Fig 1, *C–F*). Furthermore, it was found that the inactivation of cholinesterase after dosage with the anti-cholinesterases ran parallel with after-discharge.

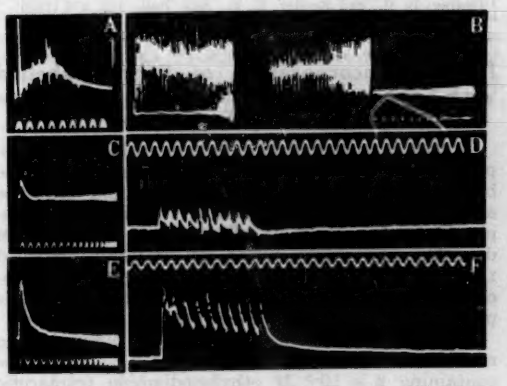

Fig. 1. Effects of eserine on postsynaptic responses. A voltage calibration of 0·5 mV. is applied to all records. Time markers are 50 c./s. except for *B*, which is 25 c./s. (*A*) Before treatment. A postsynaptic response evoked by a single presynaptic volley. A brief after-discharge. 14° C. (*B*) as in (*A*) but 47 min. after treatment with 5×10^{-5} *M* eserine. A prolonged ganglionic depolarization superimposed with discharges. Time intervals between successive records are 15 sec. All records are arranged on the same base line. (*C*) An excitatory postsynaptic potential set up by a single presynaptic volley. Under 2×10^{-3} *M* urethane 22° C. (*D*) as in (*C*) but by repetitive volleys. (*E*) as in (*C*), but 17 min. after treatment with 10^{-4} *M* eserine. An augmented and prolonged excitatory postsynaptic potential. (*F*) as in (*D*), but 41 min. after treatment with 10^{-4} *M* eserine. Augmented and prolonged excitatory postsynaptic potentials

When applied to the intact ganglion, the threshold concentration of acetylcholine for discharging impulses was as high as 10^{-2} *M*. With the eserinized or desheathed ganglion, this was lowered to 10^{-3} *M*. When the desheathed ganglion was eserinized, it was lowered to 10^{-4} *M*; although it was still about one hundred times as high as for vertebrate ganglia and skeletal muscles.

With regard to transmitter substance in the last abdominal ganglion of the cockroach, three possible explanations are suggested on the ground of the present study.

(1) Acetylcholine may be a transmitter. However, since the susceptibility of subsynaptic membrane to acetylcholine is relatively low, it is necessary for acetylcholine to be stored and liberated in large amounts and for the cholinesterase to have a high activity. A high acetylcholine content and a high cholinesterase activity are known to be the case in the cord of the cockroach.

(2) Acetylcholine may be a transmitter. However, since a certain barrier around nerve cells prohibits the penetration of applied acetylcholine, the threshold concentration is high even after desheathing and eserinizing the ganglion.

(3) The synaptic transmitter may not be an acetylcholine-like substance. The prolongation of the excitatory postsynaptic potential following treatment with anticholinesterases suggests that the transmitter is a certain ester hydrolysed by cholinesterase.

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In vitro Incorporation of Serine labelled with Carbon-14 into Mitochondrial Phospholipids

Little is known about the biosynthesis of phosphatidyl serine. It has been suggested that the biosynthetic pathway of this phospholipid might be similar to that of phosphatidyl choline and phosphatidyl ethanolamine[1]. The present investigation describes the incorporation of uniformly labelled L-serine-^{14}C into the phospholipids of rat liver mitochondria and some of the co-factors required for this process.

The mitochondria were prepared by homogenizing rat livers in ten volumes of ice-cold 0·25 *M* sucrose containing 2×10^{-3} *M* ethylenediamine tetraacetic acid, *p*H 7·4. Cell fractions were obtained by the usual fractional sedimentation[2]. The mitochondrial fraction was then washed once with the original volume of 0·25 *M* sucrose and finally suspended in 0·25 *M* sucrose (1 ml. per gm. wet weight of liver tissue). 1·5 ml. of mitochondrial suspension were incubated for 1 hr. at 37° with L-serine-^{14}C and various co-factors as outlined in Table 1. The reaction was stopped by the addition of 1/10 volume of 50 per cent trichloracetic acid. The precipitate was washed extensively with 5 per cent trichloracetic acid containing 2×10^{-3} *M* D,L-serine. The extraction of the phospholipids from the trichloracetic acid precipitate, their separation from other lipids and pigments on silicic acid columns and the determination of their specific activity by means of liquid scintillation counting was carried out, as will be described elsewhere.

Table 1. Each system contained: 1·5 ml. mitochondrial suspension in 0·25 *M* sucrose, 0·25 ml. of 1·25 *M* sucrose, 0·4 ml. of 0·1 *M* phosphate buffer (*p*H 7·4), 0·2 ml. of 0·2 *M* magnesium chloride and 5 μM of L-serine (0·5 μc.). After the addition of co-factors as indicated below, the final volume was adjusted with distilled water to 3·0 ml. Time of incubation was 60 min.

Exp.	Co-factors added (μmoles)	Specific activity (disint./min./mgm. phosphate)
1	None*	77
	None†	335
	None	1,420
	ATP (10)	2,640
	ATP (10) + CTP (2·5)	1,380
	ATP (10) + CoASH (1)	7,220
	CMP (5)	12,900
2‡	None	1,290
	CMP (5)	5,040
	CMP (5) + ATP (10)	8,660
	CMP (5) + ATP (10) + CTP (2·5)	4,810
	CMP (5) + ATP (10) + CoASH (1)	25,050

* The reaction was stopped after 0 min. of incubation.
† In this experiment the mitochondrial suspension was boiled for 5 min. prior to incubation; the system contained 10 μmoles of ATP.
‡ In experiment 2 only 2 μmoles of L-serine were added (0·2 μc).
ATP, adenosine triphosphate; CTP, cytidine triphosphate; CMP, cytidine monophosphate; CoASH, reduced coenzyme *A*.

As can be seen in Table 1, cytidine monophosphate, adenosine triphosphate and reduced coenzyme *A* all increased the incorporation of L-serine into the mitochondrial phospholipids. Cytidine triphosphate, however, which is known to be required for the incorporation of phosphoryl choline or phosphoryl ethanolamine into the corresponding phospholipids[1], did not bring about an increase in the rate of incorporation. In fact, cytidine triphosphate suppressed the increased incorporation due to the addition of adenosine triphosphate (Exp. 1). The increased incorporation due to adenosine triphosphate plus cytidine monophosphate was partly inhibited by the addition of cytidine triphosphate (Exp. 2). Since the concentration of adenosine triphosphate was the same in both these experiments, it would seem that cytidine monophosphate and cytidine triphosphate are antagonistic. These results also show that the marked increase in the rate of incorporation due to cytidine monophosphate cannot be explained by transphorylation reactions forming cytidine triphosphate from cytidine monophosphate.

The combination of the co-factors cytidine monophosphate plus adenosine triphosphate plus reduced coenzyme *A* yielded an increased incorporation which was greater than the sum of those brought about by either cytidine monophosphate, or by adenosine triphosphate plus reduced coenzyme *A*. This result suggests that all three co-factors might act in a common pathway. Further experiments showed that the optimal concentration of cytidine monophosphate was found to be $3 \cdot 3 \times 10^{-3}$ *M*, and that it could not be replaced by other 5′-mononucleotides. The optimal *p*H of the overall reaction was near 7·5. Magnesium ions (12×10^{-3} *M*) increased the incorporation of L-serine in the presence of cytidine monophosphate plus adenosine triphosphate plus reduced coenzyme *A*, whereas calcium and

fluoride ions were shown to be strongly inhibitory at the same concentration.

The radioactive phospholipid was identified by mild alkaline hydrolysis of the total phospholipids followed by separation of the resulting glycerylphosphoryl diesters on ion-exchange resins[3]. 95 per cent of the total radioactivity eluted from the resin column was found to be in the glycerylphosphoryl serine fraction, the remaining activity being in the glycerylphosphoryl ethanolamine fraction.

A more detailed report of this work will be published elsewhere.

We wish to thank Prof. A. C. Frazer for his interest and encouragement. Our thanks are also due to Miss C. Bentham for technical assistance. This work was supported by grants from the Medical Research Council.

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Distribution of Tissue-Specific Antigens in Centrifugal Fractions of Rat Liver

The microsome fraction of rat liver parenchymatous cells has been shown to contain tissue-specific antigens[1,2]. These antigens are gradually lost from the cell during the course of carcinogenesis, the hepatoma cell being virtually devoid of them[3,4]. Thus they constitute an important difference between normal and cancer cells and offer a possibility for investigating the mechanism of de-differentiation that is linked with the property of uncontrolled growth. This communication is concerned with the identification of the subcellular structures which are involved in the immunological change.

Well-defined nuclear, mitochondrial and microsomal fractions were isolated from rat liver homogenates by the methods developed by de Duve[5]. Antimicrosomal sera were prepared in rabbits and made specific for the reaction with liver by heterologous absorption with kidney microsomes[4]. The quantitative precipitin method was used for the immunological tests.

The tissue-specific microsomal antigens in the nuclei and mitochondria were determined by measuring the antibody-binding capacity of these fractions. They were incubated with the antiserum, centrifuged, and the supernatant was tested for antibody by equivalence-point determination with microsomes as antigen. No measurable amount of antibody was removed from the specific serum by the mitochondrial fraction, and the antibody-binding capacity of the nuclear fraction was about 10 per cent that of the same amount of microsomes expressed in μgm. protein nitrogen. Thus the tissue-specific antigens of the microsomes appear to be confined to this fraction only, the residual activity of the nuclei probably being due to microsomal contamination.

The microsomal material can be further fractionated into the constituents of the endoplasmic reticulum from which it is derived. Three fractions were obtained by suspending microsomes in a medium composed of 0·25 *M* sucrose, 0·08 *M* sodium citrate, and 0·01 *M* phosphate buffer *p*H 7·2 and subsequent differential centrifugation. Their characteristics are shown in Table 1. Fraction *M* represents the membranes of the endoplasmic reticulum, and contains most of the proteins and the lipids of the microsomes. Fraction *RNP* consists largely of the ribonucleoprotein particles of the endoplasmic reticulum. Membranous material is still present, however, as indicated by the lipid content. The final supernatant *S* includes proteins which are brought into solution by the citrate medium, presumably the contents of the microsomal vesicles.

Table 1. Microsomal Subfractions

	Particle size*	Protein content as percentage of that of untreated microsomes	Ribonucleic acid content as percentage of that of untreated microsomes	Ribonucleic acid content as percentage of ribonucleic acid plus protein	μgm. phospholipid phosphorus per mgm. protein nitrogen
Untreated microsomes	350	100	100	11·2	138
Fraction *M*	350	58	17	3·2	163
Fraction *RNP*	40	24	69	30	75
Fraction *S*	Supernatant	18	14	7·5	20

* Expressed in Svedberg units of the smallest particles sedimented under the conditions applied.

Comparative equivalence-point determinations were performed with the three fractions, as well as with the untreated microsomes, against a fixed volume of tissue-specific antiserum. Material containing larger amounts of the particular antigen reached the equivalence point at comparatively lower concentrations. In these experiments it was found that the antigenic activity is highest in fraction *M*, less in untreated microsomes and still less in fraction *RNP*. Fraction *S* was completely inactive in the precipitin tests. Fig. 1 shows a comparative equivalence-point determination of fraction *M* and untreated microsomes, illustrating the difference in antibody-binding capacity of the two preparations which indicates that the material removed by the citrate extraction is antigenically largely inert.

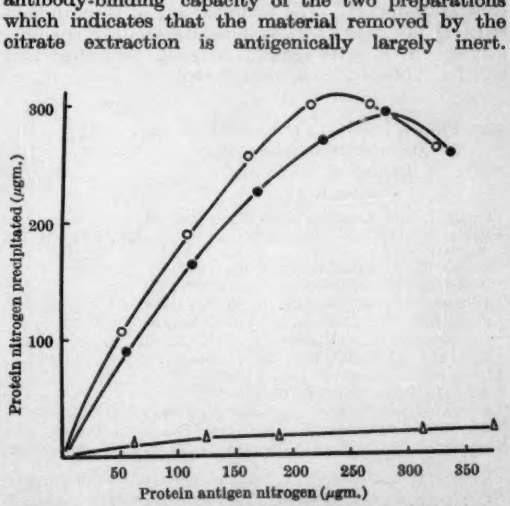

Fig. 1. ○—○, Fraction *M*; ●—●, untreated microsomes; △—△, kidney microsomes

There is a correlation between the antigenic activity of microsomal subfractions and their lipid content. If the latter is taken as a measure for the membranes of the endoplasmic reticulum this suggests that the tissue-specific antigens, probably lipoproteins, are located in these membranes.

In 48 hr. regenerating rat liver the ratio of ribonucleoprotein particles to membranes is changed by an increase of the amount of ribonucleoprotein particles[6,7]. Microsomes of such a tissue should then contain less of the specific antigens per protein weight as compared with microsomes from normal liver. This could be confirmed by equivalence-point determination.

This localization of tissue-specific substances which are known to disappear during carcinogenesis underlines the importance of organized cytoplasmic reticular structures for the state of differentiation[8]. Recent data on microsomes in cancer tissue can be correlated on the basis of the results presented above. Electron micrographs of sections from rat liver tumours induced with *p*-dimethylaminoazobenzene show only very few apparently randomly distributed membranous elements in the cytoplasm[8,9]. Glucose-6-phosphatase, an enzyme known to be bound to the endoplasmic reticulum membranes[10], is not present in the hepatoma[11]; furthermore, the phospholipid content of the microsomes is reduced[12].

On the other hand the amount of ribonucleoprotein particles is increased in the liver tumour[13]. The loss of the swelling ability of the microsomes obtained from malignant tissue[14] is best explained by an alteration in the microsomal membranes. In the normal liver parenchymatous cell the endoplasmic reticulum exhibits a high spacial organization with numerous interconnected vesicles[15]. These structures provide "conditions of semi-isolation"[16] for certain complex enzyme systems and might thus exert a regulating influence upon them. Degradation of the lamellar barriers in the course of carcinogenesis establishes free access for metabolic products and enzymes to every part of the cytoplasm, and in this way seems to contribute to the uncontrolled turnover activity of the cancer cell.

I wish to express my indebtedness to Prof. Friedrich-Freksa for his generous guidance and constant support. The financial aid of the Studienstiftung des deutschen Volkes is gratefully acknowledged. This investigation is being continued and will be published in full elsewhere.

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An Effect of Glucose on Bacteriophage Synthesis in *Salmonella typhimurium*

A mutant of *Salmonella typhimurium* has been obtained by Engelsberg (unpublished) which was characterized as 'diauxie-resistant' since, in contrast to the wild type, it could adapt itself to normally inducing substrates in the presence of glucose. The mutant was found by Engelsberg and Entner (unpublished) to contain three times as much glucose-6-phosphatase as the wild type. This enzyme difference suggests that the diauxie phenomenon can be explained by an extension of the hypothesis of Racker *et al.*[1] concerning the Crabtree effect, where it was suggested that glucose inhibits the utilization of endogenous materials by competing for the phosphate-nucleotide (adenylate) pool.

The present communication shows that an analogous glucose effect can be extended to bacteriophage synthesis. Glucose[2], bacteriophage infection[3], chloramphenicol[4], and amino-acid analogues[5] inhibit the induced synthesis of adaptive enzymes. Recently, it has been shown by Bertani[6] that during infection of some bacteria with certain temperate phages, the "selective inhibition of protein synthesis" by addition of chloramphenicol or amino-acid analogues causes a lysogenic response to be favoured over a lytic one.

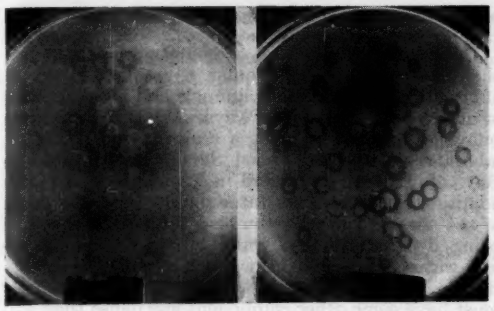
With a multiplicity of infection much less than 1, it can be demonstrated that when wild type *S. typhimurium* is infected with phage *P*22 (one of the host-parasite pairs studied by Bertani), the presence of glucose also affects the course of infection in such a way as to favour the lysogenic response (Table 1). Under the same conditions but in the absence of glucose, a lytic response occurs. As might be predicted, the diauxie-resistant mutant is lysed either in the presence or absence of glucose.

Table 1. Course of Phage *P*22 Infection in *S. typhimurium* in the Presence and Absence of Glucose (50–100 Phage added per Plate)

	Lytic response (per cent)	Lysogenic response (per cent)
Wild type		
With glucose		100
No glucose	100	
Diauxie-resistant mutant		
With glucose	100	
No glucose	100	

In the experiments the method of Adams[7] was used to obtain infection responses. To 10^8 bacteria in 2 ml. of nutrient broth containing 0·7 per cent agar (45° C.) were added 50–100 bacteriophage, and the mixture was immediately shaken and poured on top of previously solidified nutrient agar plates. Glucose when present was added to a concentration of 1 per cent just prior to addition of phage. The lytic response is shown in Fig. 1*A* and lysogenic response in Fig. 1*B*. The papillæ in the centre of the halos in Fig. 1*B* can be shown to be lysogenic clones by use of the standard method of re-streaking isolated clones until free of phage and subsequent induction of phage synthesis by ultra-violet exposure. It should be pointed out that lysogenic bacteria can be also isolated from the centre of lytic plaques, but these are lysogenized through high multiplicity of infection many cycles after the initial lytic response[8].

It would appear plausible from these experiments that glucose and bacteriophage chromosome compete for the phosphate-nucleotide pool at common sites



A B

Fig. 1

involved in protein synthesis. A virulent phage, among other things, perhaps competes more successfully for this pool than a temperate phage. In wild type *S. typhimurium* cells, glucose, by having a greater affinity for the phosphate-nucleotide pool than phage chromosome, would inhibit phage protein synthesis as it does adaptive enzyme synthesis and the use of endogenous material. Lysogeny then results. The high glucose-6-phosphatase content of the diauxie-resistant mutant allows for the continual regeneration of the phosphate-nucleotide pool, and neither adaptive enzyme nor phage protein synthesis (with resultant lysis) is inhibited by glucose. These possibilities are being further investigated.

We acknowledge the help of a Lalor Foundation Award, which made the experiments reported here possible.

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Identity of the Tetanus Toxin Receptor in Nervous Tissue

TETANUS toxin is thought to act by suppressing synaptic inhibition[1], and presumably it acts upon some substance at the inhibitory synapses in the grey matter of nervous tissue. As a possible approach to discovering the nature of this substance, the well-known Wassermann–Takaki phenomenon[2], that is, the fixation of tetanus toxin by the grey matter of nervous tissue, has been re-investigated.

Landsteiner and Botteri[3] showed that the water-insoluble sphingolipid fraction of brain had the greatest toxin-fixing capacity and believed that the cerebroside, phrenosine, was the specific toxin receptor substance; but they could not reconcile this with the fact that white matter is much richer in phrenosine than grey matter. It has now been shown that when sphingolipid suspensions are added to solutions of crude tetanus toxin, and of several other toxins, enzymes and other proteins, only the tetanus toxic protein is fixed. When the toxin is spun down with the sphingolipid, and the sphingolipid–toxin complex washed, the protein can be dissolved in alkali and estimated by the method of Lowry *et al.*[4]. It was found that 1·91 μgm. of protein was adsorbed for each $L+$ unit of toxin; this is in good agreement with the value of 2·02–2·15 μgm. protein per $L+$ unit for the pure crystalline toxin obtained by Pillemer *et al.*[5].

This specific adsorption of protein was used as the basis of an assay of the receptor. It was shown that when phrenosine was sufficiently purified it no longer fixed the toxin, and the receptor was evidently a contaminant. When crude phrenosine was partitioned between the two immiscible phases of a solvent system consisting of 15 parts chloroform, 15 parts benzene, 23 parts methyl alcohol and 7 parts water[6], little or no receptor activity could be recoverod from either phase, but full activity was recovered when the two phases were recombined. Phrenosine, mixed cerebrosides or sphingomyelin could be substituted for the lower phase component. The upper phase component was found to a greater extent in grey matter than in white, was water-soluble, and on treatment with Bial's reagent yielded a pigment absorbing maximally at 570 mμ. In these properties it resembled the mucolipids[7] (ganglioside[8], strandin[9]), and it was found that both ganglioside and strandin could be substituted for the upper phase component.

The water-soluble mucolipids form complexes with the water-insoluble cerebrosides and sphingomyelins, which tend to be soluble in water when they contain excess mucolipid, but insoluble when calcium is incorporated in the complex. Unless the receptor were insoluble in water it could not be detected by the methods employed up to this stage, which depended on spinning down the receptor-toxin complex at 5,600*g*. However, it was found that when tetanus toxin (molecular weight[10] 67,000) and water-soluble mucolipid (molecular weight[7,9] 180,000–250,000) were mixed in solution and centrifuged at 114,400*g* for 2 hr., 84 per cent of the mucolipid and 82 per cent of the toxin in the upper half of the centrifuge tube migrated to the lower half, whereas only 29 per cent of the toxin migrated in the control tube containing toxin alone. Evidently the specific fixation is between the toxin and the mucolipid.

A detailed account of this work will be published in the *Journal of General Microbiology* (**20**, No. 2; 1959).

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Loss of Sodium from the Skin of the Dehydrated Toad, *Bufo marinus*

The movement of sodium across the skin of frogs and toads has been studied extensively[1]. *Bufo marinus* placed in distilled water loses sodium from the skin at an increased rate when injected with large doses of 'Pitressin'[2]. Increase in concentration of the body fluids as in dehydration potentiates posterior pituitary hormone release in mammals, and the same appears to be the case in amphibians[3]. Therefore it was of interest to see what effect such endogenous release of posterior pituitary hormone had on loss of sodium from the skin.

The loss was measured in normally hydrated toads during a 1-hr. period on three successive days. At the beginning of each measurement they were catheterized, thoroughly washed in distilled water and then placed in 150 ml. of this water for 15 min., rinsed again and finally replaced in 150 ml. of fresh distilled water. At the end of 1 hr. a sample of the fluid bathing the toads was taken and the sodium concentration determined with an EEL-flame photometer. The total loss of sodium was then calculated from the known volume of fluid bathing the toad. Apart from the experimental periods, the toads were kept in tap water. Care in handling ensured that urine was not voided while the measurements were being made. In a second series of experiments the same toads were left without water for 48 hr. at 21° C. and 55 per cent relative humidity during which time they lost 30·0 per cent (S.E. ± 1·25) of their body-weight—a degree of dehydration from which they readily recovered if replaced in water. At the end of this period loss of sodium from the skin was measured as before.

Table 1. Loss of Sodium (mgm./hr.) from the Skin of *B. marinus* under Normal Conditions and during Hydration

Normal			Dehydrated
Day 1	Day 2	Day 3	
0·0516 ± 0·00336	0·0533 ± 0·00391	0·0582 ± 0·01232	0·3352 ± 0·06792

The results are the means ± S.E. in the same group of 15 toads (mean weight, 84·49 ± 2·800 gm.). Normal values all differed significantly from the dehydrated ($P < 0·001$).

The results are given in Table 1. It can be seen that the normal day-to-day rate of loss of sodium is remarkably constant, while in the previously dehydrated toads there is a marked increase in loss of sodium. The rate of loss is about four times as rapid as in *B. marinus* injected with large doses of 'Pitressin'[2]. The discrepancy may be due to a change in the concentration ratio across the skin and/or a change in the properties of the skin itself or to a greater effectiveness of endogenous hormone. In this latter respect it has shown that in *Bufo bufo* uptake of water is not as rapid after even supramaximal doses of posterior pituitary extracts as it is after the animals have been dehydrated[4].

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Bathyscaphoid Squid

Buoyancy equilibrium, or being of the same density as sea water, can confer a great economy of effort upon free-swimming animals and is approached or achieved in a variety of ways. While investigating buoyancy problems during a cruise of the Plymouth laboratory's research vessel *Sarsia* in the southern Bay of Biscay we found a particularly striking adaption in certain mid-water squid. Although some of the oceanic species resembled the coastal forms in being denser than sea water, the majority of the mid-water forms caught were in buoyancy equilibrium. Having neither cuttle-bone nor air sac they must have some other component less dense than sea-water (density = 1·026) to counterbalance the tendency of their proteins to sink.

These mid-water squid had enormous body cavities filled with fluid[1]. When the fluid, and it amounted to two-thirds of the squid s volume, was drained the squid sank; this showed that the buoyancy of the intact animals was given by the low densities of their coelomic fluids. From the volumes of coelomic fluid, the weights of the drained animals under sea water, and the density of that water, it was calculated that the fluid had a density about mid-way between that of distilled and sea water.

Samples of the coelomic fluid were collected from three species of mid-water squid (*Verrilliteuthis hyperborea* (Steenstrup), *Galiteuthis armata* Joubin, and *Helicocranchia pfefferi* Massy). These fluids, odourless but of bitter taste, were stored in a deep freeze and further studied on return to Plymouth.

The fluids from the three species were almost identical in composition and properties. Density-bottle measurements gave densities between 1·010 and 1·012, which accounted quantitatively for the buoyancy equilibria of the squid. Freezing point depressions were close to the value for sea water, showing that buoyancy was not achieved by simple exclusion of solutes. Of the common ions only ammonium can give a solution isotonic with sea water but of the density found. Tests indicated the presence of high concentrations of ammonium, and analyses by a method[2] insensitive to amines revealed about 480 m*M* ammonium. The sodium concentration was only about 80 m*M*, and chloride accounted for the necessary anion. (Sea water, which has chloride as its principal anion, has only a trace of ammonia but 490 m*M* sodium.)

The fluid's acidity, *p*H 5·2, was doubtless connected with the retention of ammonia in the coelom, for living tissues are permeable to molecular ammonia but relatively impermeable to the ammonium ion which predominates under acid conditions. The acidity accounted for the absence of ammoniacal smell during collection of the samples while the bitter taste of the fluid matched that of an ammonium chloride solution. We have prepared an artificial solution containing sodium and ammonium chlorides in the concentrations found in the coelomic fluid and shown that its density is close to that of the coelomic fluid.

These mid-water squid resemble the protozoan *Noctiluca*[3] in having a high concentration of ammonium ions which preserve tonicity and yet give buoyancy. In 'design' these squid are strikingly similar to the bathyscaphe, relatively recently devised by Prof. Piccard, in that their useful but dense parts are balanced by a large flotation chamber containing a fluid of lower specific gravity.

We would like to thank our colleagues at the Plymouth Laboratory for advice and help and Captain C. A. Hoodless and the crew of R.V. *Sarsia* for their enthusiastic co-operation.

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Relationships between the Chloride and Iodide Uptake of Wheat Seedlings

The theory that plants absorb ions by the action of carriers has become general during the past decades. It is an intermediate labile complex, formed by a combination of the carrier and the ion, which traverses the membrane impermeable to free ions. Upon arriving at the inner surface, the complex breaks down and releases the ion carried by it. Epstein *et al.*[1] suggest that different carriers are involved for different groups of ions. A common carrier mechanism is, for example, operative for chloride, bromide and iodide ions[2]. It was demonstrated a few years ago that two separate systems of carriers act in the uptake of differently dissociated phosphate ions[3], while, recently, likewise two separate carriers have been postulated for the absorption of monovalent cations[4]. It has thus become necessary to collect additional data concerning the uptake of monovalent anions.

The results of experiments performed by Sutcliffe[5] with disks of red beetroot point to the possibility that mutual interference between the uptake of different alkali ions is more intricate than used to be supposed. If an ion A is a competitive inhibitor of the uptake of another ion B, the latter may either inhibit or stimulate the uptake of A, according to whether the carrier exhibits a preference for its absorption. Sutcliffe claims the existence of such interaction between sodium and potassium. We are not aware of this kind of correlation between other pairs of ions, probably for the reason that mutual interference between the uptake of different ions has been investigated mostly in one direction only.

Seedlings of winter wheat, variety *F.* 481, were used in our experiments. We sterilized the seeds with hydrogen peroxide and then germinated them in Petri dishes for two days at a temperature of 26° C. The seedlings were transferred to perforated disks and the latter placed upon the surface of a tenfold-diluted Hoagland solution. The plants were then grown for two more days in the nutrient solution at 21° C. After this, the seedlings, with the perforated disks, were transferred to Lundegårdh vessels for the purposes of 24-hr. experiments, which, like the growing of the seedlings, were performed in the dark, in a damp atmosphere.

Combining five chloride- and five iodide-levels (0, 0·5, 5, 25 and 50 m.equiv.) we obtained twenty-five variants. At the termination of the experiment, the roots were twice rinsed with distilled water, after which the roots and the shoots were dried separately. (Seeds were not analysed.) The samples were burnt

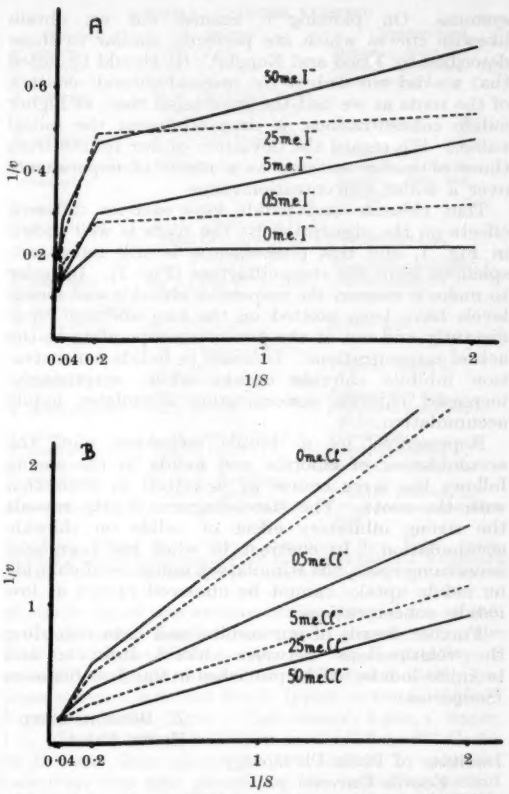

Fig. 1. The action of iodide levels on the accumulation of chloride (*A*), and the action of chloride levels on the accumulation of iodide (*B*) in the roots

in oxygen[6], and this was followed by electrometric titration. After having acidified the solution, the released iodine was dissolved in chloroform and measured photometrically. Uptake is given in μ.equiv. in respect of the test plants used in each variant. Figures represent the mean value of results from two replications.

As usual, the reciprocal of the rate, at which the roots accumulate chloride and iodide, $1/v$, is plotted against the reciprocal of concentration $1/S$ (Fig. 1, *A* and *B*). Lines so obtained are characteristically curved for both ions: this points, according to the kinetic analysis, to the participation of two carrier

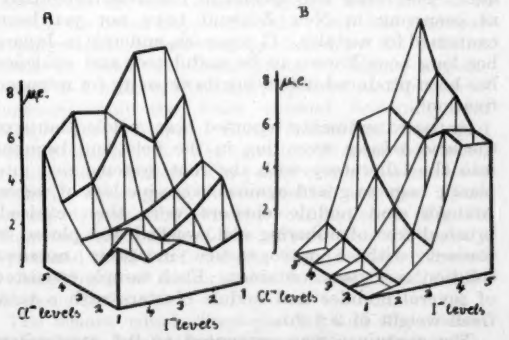

Fig. 2. The relationship between chloride and iodide in the chloride (*A*), and iodide (*B*) accumulation of the roots

systems. On plotting v against v/S we obtain likewise curves which are perfectly similar to those described by Fried and Noggle[4]. (It should be noted that we did not deduct the original chloride content of the roots as we had the impression that, at higher iodide concentrations, it dropped below the initial value.) We regard the deviation of our results from those of earlier authors as a result of experiments over a wider concentration-range.

That chloride and iodide ions exercise different effects on the absorption by the roots is well shown in Fig. 1, and this phenomenon is still more conspicuous from the stereo-diagram (Fig. 2). In order to make it clearer, the respective chloride and iodide levels have been plotted on the two abscisse equidistantly and not at the points corresponding to the actual concentrations. Increase in iodide concentration inhibits chloride uptake while, surprisingly, increased chloride concentration stimulates iodide accumulation.

Represented by a double reciprocal plot, the accumulation of chloride and iodide in the shoots follows the same course as described in connexion with the roots. The stereodiagram clearly reveals the strong inhibitory effect of iodide on chloride accumulation. In contrast to what has been said concerning roots, the stimulatory influence of chloride on iodide uptake cannot be observed except at low iodide concentrations.

Further details of our results, and data regarding the relationships between chloride–bromide and bromide–iodide, will be published in the *Acta Botanica Hungarica*.

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Fixation of Nitrogen-15 by Excised Nodules of *Coriaria arborea* Lindsay

Bond[1] has recently directed attention to the occurrence of root nodules on species of *Coriaria* growing in New Zealand. We have found nodules on young plants of *C. arborea* but not on *C. sarmentosa*. The other five species of *Coriaria* recognized[2] as occurring in New Zealand have not yet been examined for nodules. *C. japonica*, endemic in Japan, has long been known to be nodulated, and evidence has been produced indicating its capacity for nitrogen fixation[3].

In the experiments reported here, whole plants of *Coriaria arborea* were dug in the field and brought into the laboratory with the root systems tied into plastic bags to guard against excessive loss of water. Nodules and nodule clusters were then excised, brushed free of adhering soil, washed and placed in contact with a nitrogen-free inorganic nutrient solution in a glass container. Each sample consisted of several nodules and nodule clusters with a total fresh weight of 3·4 gm.

The container was evacuated to 0·5 atmosphere and then the pressure was restored to atmospheric by the introduction of nitrogen containing approximately 60 atom per cent nitrogen-15. The gas mixture surrounding the nodules now contained approximately 10 per cent oxygen and 90 per cent nitrogen with 30 atom per cent excess nitrogen-15. The time-intervals between digging the plants and exposing the nodules to nitrogen-15 did not exceed 50 min. The nodules were left in the darkened container for 24 hr. at laboratory temperature of 27 ± 2° C. and then extracted with 3 *N* hydrochloric acid[4]. The extract of a single sample contained approximately 3·0 mgm. nitrogen. Distillates from Kjeldahl digestions of the extracts were submitted for nitrogen-15 assay to the Division of Nuclear Sciences of the Department of Scientific and Industrial Research.

Acid extracts of three samples of nodules were found to contain 0·89, 0·71 and 0·51 atom per cent excess nitrogen-15, giving clear evidence of the fixation of nitrogen-15.

We wish to thank Mr. J. A. Rafter, director of the Division of Nuclear Sciences, Department of Scientific and Industrial Research, and Dr. A. D. Campbell of the Chemistry Department, University of Otago, for their advice and collaboration in this work which has been aided by a grant from the University of New Zealand Research Fund.

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Growth-promoting Effect of Ethanol on Oat Seedlings

The effects of carbon dioxide on the growth of etiolated oat seedlings[1]—promotion of the mesocotyl and depression of the coleoptile—have been under investigation for some time[2,3] and the observed behaviour has been attributed to a prolongation of the activity of the nodal meristem[3]. Attempts have recently been made to correlate these growth phenomena with auxin metabolism by supplying indoleacetic acid (10 p.p.m.) to intact oat seedlings via their roots. In these experiments promotion of the mesocotyl was observed when ethanol was used as the solvent for indoleacetic acid but not when the potassium or ammonium salts were used dissolved in water. The effects on growth of 0·2 and 0·3 per cent ethanol were investigated, and they occasioned growth responses which exactly parallelled those induced by carbon dioxide.

The measurements of fifteen replicates per treatment (mm.) recorded in Table 1 were derived from an experiment in which plants were pretreated in darkness with ± carbon dioxide (5 per cent) ± ethanol (0·3 per cent) for 3 days from the time of planting, after which one set was exposed to dim red light (1 foot-candle) for 5 min. while the other set remained in darkness, and these were measured when 7 days old. The duplicate initial measurements (3 days old) thus estimate the lengths of the plant organs at the time of exposure to light, and, since no further treatment with ethanol and carbon dioxide was given, the subsequent growth responses were after-effects.

Table 1. Lengths, in mm., attained in Three Days by Oat Seedlings before Illumination. Each Entry is the Mean of Fifteen Replicates

Carbon dioxide	+	−	+	−	+	−	+	−
Ethanol	+	+	−	−	+	+	−	−
Mesocotyls	10·3	16·1	21·1	32·7	11·2	15·9	22·1	31·8
Coleoptiles	4·7	7·3	6·8	12·1	4·5	6·8	7·1	10·3

Lengths of plants (mm.) when seven days old

	Illuminated				Not illuminated			
Mesocotyls	76·2	57·4	56·7	46·0	123·7	91·6	96·8	58·0
Coleoptiles	48·5	58·6	63·1	66·0	43·8	60·8	61·6	72·8

The growth of both mesocotyls and coleoptiles was depressed by each factor during pretreatment, and the administration of both simultaneously was more depressive than either singly.

Between 3 and 7 days in darkness both treatments induced promotion of the mesocotyl to approximately the same extent (increment 33·6 and 38·8 mm.) while the combined effect (increment 65·7 mm.) was almost equal to the sum of the individual effects. After illumination the untreated mesocotyls (−carbon dioxide, −ethanol) increased in length by 13·3 mm., but the depressive effect of light was almost eliminated by pretreatment with either carbon dioxide or ethanol (compare 56·7 and 57·4 with 58·0 mm.), while the combined effect was promotive (compare 76·2 with 58·0 mm.). These treated plants were nevertheless very sensitive to light, which depressed mesocotyl growth from 123·7 mm. to 76·2 mm., a proportionately greater decrease than that shown by the controls 58·0 to 46·0 mm.); similarly with each factor separately.

In connexion with the suggestion that carbon dioxide prolongs the meristematic phase, it may now be said that ethanol does likewise, and it is therefore of great interest that it has recently been shown that ethanol stimulates cell division in algæ[4,5].

Further data and a discussion of the significance of these findings will be published shortly. Meanwhile the matter is under investigation.

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Host Specificity in *Xanthomonas*

Burkholder and Starr[1] stated that "unequivocal identification by laboratory procedures of all *Xanthomonas* species is as yet an impossibility", and there has been no change in this position in recent years[2,3]. The diagnosis of *Xanthomonas* species therefore depends on the host specificity of the organisms. Wernham[4] inoculated cultures of fourteen pathogenic *Xanthomonas* into twelve different hosts and found them to be "remarkably specific in their host reactions". He also stated that "there is no possibility of error in using the host as a species determiner". However, since the host ranges of most of the organisms have never been completely determined the classification of the genus is not securely established.

Recently, some cross-inoculation tests were carried out as follows: bean plants (*Phaseolus vulgaris* L.) variety Canadian Wonder, were grown from seed in sterilized soil in sterilized 4-in. pots. When the first trifoliate leaves were half developed the plants were placed for 24 hr. in a cabinet into which a fine mist of sterile water was automatically sprayed for 45 sec. every 30 min. Leaflets were then punctured in the midrib with a sterile needle. A small quantity of each of the *Xanthomonas* cultures listed in Table 1 in yeast-extract nutrient broth (yeast extract, 'Difco', 5 gm.; peptone, 5 gm.; 'Lab-lemco', 5 gm.; water, 1 l., *p*H 6·8) which had been incubated at 27° C. for 24 hr. was then placed on the leaflets by pipette. Inoculum was also placed on the unfolding second trifoliate leaves, which were not punctured. Each plant was immediately covered with a transparent plastic bag which was tied tightly around the pot in order to provide a humid atmosphere about the plant. After 3–5 days the plants were examined and isolations were made from lesions. If no lesions were apparent isolations were made from the points of needle puncture. Xanthomonads were re-isolated without difficulty in all instances. Three isolates, each from a different lesion or puncture, were incubated for 24 hr. in yeast-extract nutrient broth. The three cultures were then mixed and inoculated into fresh bean plants as before. The object of combining the three isolates was to reduce the chances of using non-pathogenic mutants. The process of inoculation, isolation and re-inoculation was carried out four times. On the last occasion lesions were allowed to develop for seven days before the result was recorded. A progressive disease was produced by the cultures listed in Table 1. Dark green to black, angular lesions 2–4 mm. in diameter appeared at the sites of puncture, and the veins showed browning and collapse for 3–5 mm. Some lesions as they aged became light brown. Yellow chlorotic areas developed around many lesions. On parts which had not been pricked, dark green water-soaked angular spots developed, particularly on the younger leaves (Fig. 1). When lesions coalesced the effects were frequently severe and caused defoliation. Some lesions extruded a slimy mass of bacteria which were found to be xanthomonads.

Table 1. Cultures Examined

Species	Source*	Normal host
X. alfalfae	ITCC (*B* 37)	*Medicago sativa* L.
X. begoniae	NCPPB (241)	*Begonia boliviensis* D.C.
X. beticola	ITCC (*B* 45)	*Beta vulgaris* L.
X. betlicola	M. K. Patel (11), India, via M.P. Starr (*XB* 104), U.S.A.	*Piper betel* L.
X. campestris	E. Billing (*P* 25), Wye, U.K.	*Brassica* spp.
X. campestris var. *armoraciae*	NCPPB (347)	*Amoracia rusticana* Gaertn., Mey and Scherb.
X. citri	D. W. Dye (*R* 3), N.Z.	*Citrus* spp.
X. geranii	ATCC (11056), via M. P. Starr (*XG* 1) U.S.A.	*Pelargonium* spp.
X. hyacinthi	A. F. G. Slootweg (18-*X*), Holland	*Hyacinthus orientalis* L.
X. juglandis	D. W. Dye (*S* 14), N.Z.	*Juglans regia* L.
X. malvacearum	NCPPB (293)	*Gossypium* spp.
X. nigromaculans f. sp. *zinniae*	NCPPB (189)	*Zinnia* spp.
X. papavericola	W. H. Burkholder via M. P. Starr (*XP* 17), U.S.A.	*Papaver rhoeas* L.
X. pelargonii	E. Hellmers (69), Denmark	*Pelargonium* spp.
X. poinsettiaecola	ITCC (*B* 46)	*Euphorbia pulcherima* Willd.
X. pruni	D. W. Dye (*T* 8), N.Z.	*Prunus* spp.
X. punicae	NCPPB (466)	*Punica granatum* L.
X. ricinicola	ITCC (*B* 48)	*Ricinus communis* L.
X. translucens	W. A. F. Hagborg (3068), Canada	*Triticum aestivum* L.
X. vesicatoria	D. W. Dye (*X* 3), N.Z.	*Lycopersicum esculentum* Mill.

* ITCC, Indian Type Culture Collection, New Delhi, India; NCPPB, National Collection of Plant Pathogenic Bacteria, Harpenden, Britain; ATCC, American Type Culture Collection, United States.

The lesions which developed without the tissues having been damaged were regarded as good reproductions of natural infection and were considered as

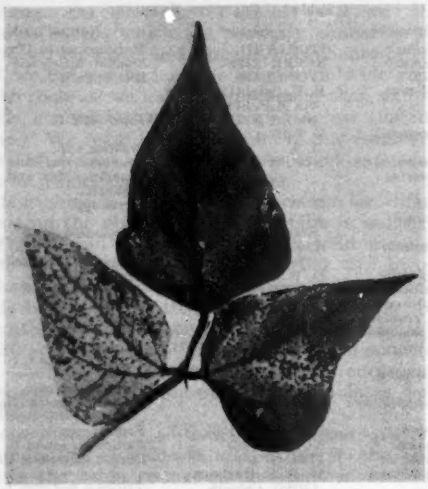

Fig. 1. The typical effects produced on bean leaves by the various species of *Xanthomonas*

proof that the bacteria had become adapted to their new host. This type of infection could not invariably be distinguished from that caused by *X. phaseoli*, though this organism frequently caused a more extensive pale green necrosis and wilting. It seems possible that the organisms originally isolated from other hosts would, with further adaptation to the bean, produce symptoms identical with those due to *X. phaseoli*. Single-colony isolates were in each case shown to be indistinguishable in cultural and physiological properties from their parent culture. The ability of *X. phaseoli* var. *fuscans*, *X. punicae* and *X. ricinicola* to produce a brown stain in media was a convenient label for these organisms, and provided evidence that unintentional cross-infections did not occur.

There seems to be no reason to suppose that the inoculations were carried out under unnatural conditions. Actively growing bacteria were merely applied in sufficient numbers to susceptible parts of bean plants under the conditions of humidity and temperature which commonly promote infection in temperate and sub-tropical climates. The findings suggest the possibility that a similar result might be obtained with other hosts and that the host specificity of the xanthomonads may not be a stable character. The fact that cultures originally isolated from twenty different hosts can infect bean plants is, at the least, evidence of a close relationship among these organisms.

I am grateful to the New Zealand Fruitgrowers Federation, Ltd., and to the Department of Scientific and Industrial Research, New Zealand, for financial assistance which made this work possible.

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Preparation of Virus Antisera from Strawberry

Strawberry contains tanning agents in such quantity that water extracts of strawberry leaves contain no appreciable amounts of protein and will, moreover, precipitate serum proteins, thus being unsuitable for serological work with viruses that infect the plant[1]. This is also true of other rosaceous plants, and thus most workers have tried to find other hosts for viruses affecting members of the Rosaceae before attempting the preparation of specific antisera.

It now seems that this step is not necessary in preparing antisera to some viruses from rosaceous plants, since by the use of recent techniques for the removal of tanning agents from leaves during maceration[2], satisfactory antisera have been prepared to two viruses from strawberry leaves, namely, raspberry ringspot virus from the variety Huxley, and raspberry yellow dwarf virus from the variety Cambridge Favourite. Both these are soil-borne viruses which are widespread and of local importance in strawberry in Scotland, and they can be transmitted mechanically from strawberry to a number of herbaceous host plants[3].

In each case, leaf extracts were prepared by the following method, found to give a high yield of virus in preliminary investigations in which extracts prepared in various ways from Huxley strawberry infected with raspberry ringspot virus were assayed on the leaves of *Chenopodium amaranticolor* (Coste and Reyn.) plants.

Mature leaves harvested from infected plants in the field were shredded and then ground in a mortar with an equal weight of 5 per cent nicotine base and sufficient coarse carborundum powder to ensure thorough maceration. The liquid expressed by squeezing the macerate through muslin was then clarified by slow-speed centrifugation and dialysed against running tap-water overnight to remove excess nicotine. After further dialysis against 0·85 per cent saline, the preparations were stored frozen. Antisera were prepared by the intravenous injection to rabbits of 2 ml. aliquots of these preparations at twice-weekly intervals over a period of three weeks. Both antisera were of moderately high titre—about 1/256—measured by precipitin tests against clarified sap from infected leaves of *Petunia hybrida* Vilm. This titre compares well with those obtained using infected *P. hybrida* or *Nicotiana tabacum* L. as the source of virus[4]. It is of interest that the viruses in preparations made in this way did not give a visible precipitate when incubated with their homologous antisera, but did so only if concentrated after precipitation with acetone.

It is thought that this method, refined by the use of ultracentrifugation or freeze-drying, may be of value in preparing antisera to other viruses directly from rosaceous hosts. A fuller account of the development of the method is to be published elsewhere.

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Sol-Gel Transitions in the Living Cells of Conifers and their Relation to Resistance to Cold

THE cause of cold hardiness changes in over-wintering phanerophytes has long been sought in the characteristics of the cytoplasm. Yet there are sharp disagreements on whether the cytoplasm becomes more viscous or less viscous in winter. At the same time the characteristics of the vacuole have not been so carefully studied by cytologists. Both Iljin and Rouschal[1], however, believed that the extraordinary drought resistance of certain ferns was related to the ability of the vacuoles to gelate.

Such a gelation could occur in the leaves and bark of over-wintering plants like pines and thus stabilize the cytoplasm against distortion during the dehydration accompanying ice formation. Gelation of the cell contents of trees has been mentioned in the literature; but observations are not supported by clear evidence. Some have felt that the gelation is 'protoplasmic', at least in cambial cells of trees[2]; yet others have left it open to question as to the exact part of the cell gelating[3,4]. In the meantime, others have concluded that the cytoplasm becomes more fluid in winter than in summer[5], so that gelation or even increased viscosity (an idea supported by numerous workers) would seem unlikely. Observations of protoplasmic streaming in pine cambial cells[6] would seem to throw light on the matter; but protoplasmic streaming is probably not a good measure of viscosity, and streaming is commonly lacking in many of the mature living conifer cells in any season.

In our work it became clear that in the endodermis and transfusion parenchyma cells of the leaves of *Pinus ponderosa*, *P. strobus* and *P. monticola*, the vacuoles pass from a sol to a gel condition in the late autumn, that is, from a liquid of about 3 on the viscosity scale of Seifriz[7] to one of about 8. This was indicated by a marked slowing down and finally a cessation of Brownian movement of vacuolar particles. It is believed that this phenomenon may contribute to, although not explain, the autumn hardiness increases.

Another curious thing observed in the course of seasonal microscopic studies of *P. strobus* bark cells was that the starch grains sink down in the ray cells due to gravity alone in January and remain thus into March. At the same time nuclei in the adjacent vertical phloem parenchyma were often found to be acropetal. In summer it was necessary to centrifuge bark cells at 1,500 r.p.m. in order to throw down the starch grains. This suggests a decreased cytoplasmic viscosity in winter, to use the terminology of Heilbrunn[8], and might even be considered a gel-to-sol transition.

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Genetical Interference in *Drosophila* spp.

IN chromosomes II and III of *D. melanogaster* Owen[1] found good agreement with the interference function $4u\exp(-2u)$ which is distributed as $\frac{1}{4}\chi^2_4$. In the *X*-chromosome the position was more doubtful, possibly due to misclassification, which tends to inflate the rare double recombinant classes in multi-point linkage tests, hence altering the estimates of the intensity of interference.

It was therefore thought profitable to examine back-cross linkage data involving three or more genes in some of the other species of *Drosophila*. The method of analysis has been sketched by Parsons[2,3]. This involves plotting the Kosambi coefficient[4], *K*, against the mean of the map distances for each three point test. On the $\frac{1}{4}\chi^2_4$ metric, $K = 1$ at the metrical mid-arm of long chromosome arms, which corresponds to a point one-third of the map distance from the centromere. Closer to the centromere $K > 1$, and farther from it $K < 1$. Thus graphs of *K* against the mean of the map distance may be compared with an expected graph, and if the centromere can be located accurately the observed metrical mid-arm may be compared with the expected, as has been done for maize[2,3].

Data for the six species *D. simulans*, *D. virilis*, *D. sub-obscura*, *D. prosaltans*, *D. pseudo-obscura* races *A* and *B* and *D. willistoni* were examined. In many cases the *K* values were very variable. Some of the variability was removed by eliminating genes prone to misclassification, but some remained, and may possibly be due to gonial crossing-over[5]. In the data for *D. prosaltans*[6], for example, cross-over values and hence *K* values varied enormously. In the *X*-chromosome the *K* values increased towards the centromere, showing that interference is less intense near the centromere. In chromosomes II and III, the situation was not obvious, possibly due to a lack of data.

On the whole, however, with the exception of the *X*-chromosome of *D. virilis*, the *K* values were less scattered, and a definite graph of *K* increasing towards the centromere could be drawn for the *X*-chromosomes of *D. simulans*, *D. pseudo-obscura* race *B* and *D. willistoni* (Brazilian and Cuban strains), chromosome II of *D. simulans* and *D. pseudo-obscura* race *A*, and chromosome III of *D. pseudo-obscura* race *A*. In the *X*-chromosomes of *D. sub-obscura* and *D. pseudo-obscura* race *A*, and chromosome III of *D. simulans* there was no apparent trend, but the points did not disagree with expectation. For the remainder of the chromosomes the data were inadequate.

Thus the well-established phenomenon of interference becoming more intense with distance from the centromere is not contradicted. However, on the whole, the data are very much more variable than in maize[2,3], and testing them against a specific metric does not appear to be possible. It can be said that it is unlikely that interference is much more severe than that predicted by the $\frac{1}{4}\chi^2_4$ metric, for on the $\frac{1}{6}\chi^2_6$ metric developed by Payne[7], *K* is expected to be $< 0{\cdot}3$ at 20 to 30 centimorgans from the centromere. Most of the observed values in this region were much closer to unity, which represents the degree of interference predicted by the $\frac{1}{4}\chi^2_4$ metric.

However, it cannot be expected that all the data will fit one metric, since a metric, like recombination, varies according to genetic and environmental conditions. To specify the situation fully, it is probable that a family of interference functions of similar form will be needed. Behind every interference function there must be some basic assumption,

which, on observations and theory to date, must be[1,4]: (1) no interference across the centromere; (2) independent distribution of intercept-lengths when measured on an interference metric; (3) no repressive effect of the terminus on chiasma formation. Presumably, therefore, each metric will be of similar form. A small adjustment will allow for changes of the environment or genetic background, and in some organisms, such as the house mouse[2], a different metric will be needed for each sex.

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Resistance to Pyrethrins and to Pyrethrins - Piperonyl Butoxide in a Wild Strain of *Musca domestica* L. in Sweden

Although synergized pyrethrins have been used for fly control for many years, there is no published record of *Musca domestica* L. becoming resistant to this insecticide in the field.

During 1947–56, the fly population of a farm (Wasa) near Stockholm had developed high resistance to many of the chlorinated hydrocarbon insecticides and some resistance to parathion. Commercial insecticides containing pyrethrins and the synergist piperonyl butoxide were used in the latter part of 1956 and early 1957, but by October of that year it was reported that they no longer killed the flies.

Larvæ and pupæ of *Musca domestica* L. were collected at this farm and bred under standard conditions at the Statens Skadedyrlaboratorium, Springforbi, Denmark, and the Cooper Technical Bureau, Berkhamsted, England.

At Springforbi the resistance of the first and later generations was measured by topical application to the dorsal thorax of female flies of a mixture of pyrethrins plus piperonyl butoxide (1 : 10) dissolved in acetone. The mortality was observed after 24 hr. and the median lethal dose (*LD*50) per 20 mgm. of fly estimated from plotted regression lines. Comparative tests were carried out with laboratory strains representing various resistance patterns, which, as far as we know, have not been exposed to selective treatment with pyrethrins.

Table 2. Resistance to Pyrethrins and to Pyrethrins plus Piperonyl Butoxide of a Wild Strain of *Musca domestica* L. collected from a Farm in Sweden
Spray tests with oil solutions. (Means of six replicate tests)

Strain of *Musca domestica* L.	Percentage concentration (w/v) of insecticide: Pyrethrins	Piperonyl butoxide	Percentage mortality in 24 hr.	*LD*50 (percentage concentration)	Resistance	*KD*50c (min.)
Laboratory	0·10	—	14	0·32	1	2·60
	0·25	—	45			1·75
	0·40	—	54			1·30
	0·50	—	61			1·15
Swedish (Wasa)	3·25	—	35	4·00	12·5	>10
	4·00	—	51			>10
	5·00	—	58			>10
	7·00	—	82			>10
	10·00	—	87			>10
Laboratory	0·03	0·24	42	0·041/0·328	1	4·20
	0·04	0·32	48			3·30
	0·05	0·40	65			3·10
	0·075	0·60	91			2·30
Swedish (Wasa)	0·30	2·40	21	0·44/3·5	10·7	>10
	0·50	4·00	59			>10
	0·625	5·00	83			>10
	0·75	6·00	93			>10

The results (Table 1) showed that the *LD*50 of the Wasa flies (3·3 μgm.) was 11–14 times that of the susceptible strains Eno and 7. After seven generations in the laboratory without exposure to insecticides, the resistance of the Wasa strain decreased significantly but was still remarkably high (2·1 μgm.).

Moreover, the Wasa strain showed high resistance to chlorinated hydrocarbons, and the *LD*50 obtained with the organo-phosphorus compounds, 'Diazinon' (1·2 μgm.; 30 times normal) and parathion (0·13 μgm.; six times normal) was comparable to the highest measured in Danish field-populations[1].

The laboratory strains which were resistant to chlorinated hydrocarbons or organo-phosphorus compounds are also more tolerant to synergized pyrethrins than normal (2–4 times). This indicates that the resistance to synergized pyrethrins is partly due to non-specific factors ('vigour tolerance') and partly to specific defence mechanisms against synergized pyrethrins.

At the Cooper Technical Bureau the resistance of the F_2 generation to pyrethrins, and to pyrethrins plus piperonyl butoxide in a ratio of 1 : 8, was compared with that of the normal laboratory stock. Flies were sprayed with solutions of these insecticides in odourless kerosene. A modification of the direct-spray technique evolved by Kearns and March[2] was used.

Table 1. Tolerance to Pyrethrins and Piperonyl Butoxide of a Swedish Strain (Wasa) of *Musca domestica* L. compared with Danish Strains
Topical application of acetone solutions

Strains	Year of collection	Resistance to: DDT	Lindane	Chlordane	Organo-phosphorus compounds	Tolerance to pyrethrins/piperonyl butoxide, 1 : 10: *LD*50 μgm. per female fly (20 mgm.) with 95 per cent confidence limits	Slope
Swedish Wasa F_1	1957	+++	++	+++	++	3·3 (2·9–3·7)	6·3
Wasa F_2	1957					2·1 (1·8–2·4)	6·3
Danish No. 7	1948	(+)	−	−	−	0·24 (0·19–0·30)	4·0
Eno	1955	−	−	−	−	0·31 (0·27–0·37)	8·8
No. 17e	1950	++	++	++	−	0·55 (0·45–0·68)	5·1
No. 150a	1955	+			+	0·52 (0·43–0·63)	4·3
No. 203a	1957	+++	++	++	++	0·98 (0·76–1·29)	2·4

Symbols for resistance: +++, high; ++, moderate; +, slight; −, none.

The concentration of insecticide required to give 50 per cent mortality (*LD*50) was calculated for each insecticide with each strain of flies from log-probit regression lines. Knock-down was recorded in addition to the percentage mortality and the *KD*50 (time taken to knock down 50 per cent of flies) obtained with each solution was calculated.

The results (Table 2) showed that the Wasa strain was 12·5 times more resistant to pyrethrins, and 10·7 times more resistant to pyrethrins plus piperonyl butoxide, than the normal laboratory strain. Resistance to the knock-down effect of these insecticides was also shown.

It may be of interest to other workers to note that preliminary tests carried out at the Cooper Technical Bureau have indicated a resistance to 'Allethrin' and to 'Allethrin' with piperonyl butoxide. Using a measured drop technique, resistance to 'Allethrin' was about 150 times, and to 'Allethrin' with piperonyl butoxide about 45 times, that of the normal laboratory strain.

The conditions for development of this reported resistance seem to have been especially favourable in Sweden during the past few years. As the chlorinated hydrocarbons and organo-phosphorus compounds failed to control the flies, dusts with a low content of synergized pyrethrins (at Wasa 0·075 per cent pyrethrins plus 0·6 per cent piperonyl butoxide) were used widely throughout the fly seasons, and flies were exposed to a wide range of dosages as the pyrethrins deteriorated. In addition, aerosols containing concentrations of synergized pyrethrins below that normally required for adequate fly control were used. Increasing difficulty in killing flies with pyrethrum insecticides, both dusts and aerosols, was reported from several places in Sweden in 1957, but the resistance was not measured by laboratory tests.

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Changes in the Tiller Population of Grass Swards

One of the characteristic attributes of perennial herbage grasses is their ability to produce tillers in large numbers. Since each tiller, in passing through its life-cycle, lives for a variable but limited amount of time, the growth of the plant will reflect the sum of the individual life-histories of its tillers. There is continuous change throughout the year as new tillers appear and others decay, so that counts of tillers at any one time represent no more than a census of an ever-changing population.

Discernible seasonal trends in the number of tillers present in the sward have been shown in several species. The indications are that density of tillers increases after the summer, possibly continuing into the winter, but that after the onset of active growth in the spring a marked decline occurs[1,2] which may be prolonged and severe if growth is allowed to proceed uninterruptedly[3]. A cut at the hay stage when ears have emerged will remove large numbers of tillers which may not be replaced immediately, thus leading to a further decrease in the tiller population.

Table 1. Number of Living Tillers present per 1 sq. ft.

1958	Hay and aftermath		Frequent cutting	
	Meadow fescue	Timothy	Meadow fescue	Timothy
March	606	526	823	775
April	578	542	822	775
May	522	361	718	675
June	504	264	484	504
July	524	319	516	550
August	439	314	531	614

Recent experiments, in which the performance of individual tillers of plants growing in large containers but otherwise under field conditions has been followed, suggest that these fluctuations in number are accompanied by considerable changes in the composition of the population in respect of age, as tillers come and go. These changes do not appear to be confined to swards which are cut for hay after flowering has occurred, as would have been expected, but also occur in frequently defoliated swards in which inflorescences are not allowed to appear.

Table 1 shows the results of a census of the number of tillers starting in March 1958 and repeated at intervals of 4 weeks. The swards under investigation were either *S*.215 meadow fescue or *S*.48 timothy sown without clover in 1956 and subjected to one of two managements: cutting for hay and aftermath, or frequent cutting (every 4 weeks beginning early in April). Both grasses maintained a greater population of tillers in response to frequent cutting than under the hay and aftermath system. Within each treatment, tiller numbers tended to be high early in the year but they declined after the middle of April, whether the swards had been cut by that time or left to grow until ears had emerged (late May in meadow fescue, late June in timothy).

These seasonal variations in number were accompanied by marked changes in the composition of the tiller population, as shown by the number of new and dead tillers at each date of observation (Table 2). For the purpose of this study no distinction was drawn between tillers which had died from natural and unspecified causes, and those that had been killed by having their apical meristem removed through cutting.

In both meadow fescue and timothy, cutting for hay after ears had emerged led to heavy casualties among tillers, but replacement appeared to be rapid and roughly proportional to the losses sustained. As

Table 2. Number of New and Dead Tillers per 1 sq. ft.

1958	Meadow fescue		Timothy	
	New	Dead	New	Dead
Hay and aftermath				
March	34	26	42	22
April	29	57	27	11
May	35	91	2	183
June	226	269	138	229
July	70	50	146	96
August	39	124	77	82
Frequent cutting				
March	74	41	23	22
April	21	42	37	37
May	52	156	16	116
June	98	332	234	404
July	40	9	236	167
August	57	42	122	58

a result, a large part of the tiller population in August was of fairly recent origin. Similar changes also occurred under a system of repeated defoliations, although ears were never allowed to appear. Thus in timothy, about 690 tillers per sq. ft. died or were decapitated between May and July, while some 490 new tillers appeared. Heavy losses were also recorded in meadow fescue; replacement was less rapid, but the results obtained in the previous year suggested that in this grass tillering continues actively into the winter. Although no marked fluctuations in tiller numbers could be detected, there had nevertheless been considerable change in the composition of the tiller population, with most of the older tillers disappearing and new ones taking their place.

A large part of these internal changes was no doubt attributable to the fact that many tillers had moved from the vegetative to the reproductive condition at a time determined by the day-length requirements of the plant. After this transition had gone some way, internode elongation will have occurred, so that in course of time differentiated shoot apices were lifted sufficiently high above the ground to become vulnerable to cutting. This would account for the high casualties sustained by both grasses around the time when they usually flower if allowed to produce ears.

In consequence of this striking loss and replacement of tillers, the composition of swards in August was very different from that earlier in the year. It may be suggested that these differences play a part in the seasonal pattern of dry-matter production in the grasses. Tillers which appear in the autumn or winter are usually well established by the time environmental conditions favourable for growth arise in the spring. There then follows a period of intense accumulation of dry-matter, characterized by exceptionally high growth-rates[3] and continuing to around the time when flowering occurs. Whether inflorescences are allowed to emerge or not, a cut taken after internode elongation has gone some way will result in the removal of a large part of the older tillers and their replacement by new shoots. Since very young tillers appear to go through a period of establishment[4], the plant may not be able to continue production of dry-matter at the same rate as in the pre-flowering period, before the tiller complement was changed. This may be more noticeable under difficult climatic conditions and in strains which naturally flower late and thus produce tillers when some environmental factors are no longer optimal. It is thus possible that the decline in the productivity of grasses commonly experienced in the summer is connected with the change in the tiller population, even though no indication of this can be obtained from tiller counts. The suggestion of breeding non-flowering strains to overcome this problem has already been put forward[5], although there may possibly be other means of ensuring that a greater proportion of the tillers present early in spring survive through the summer and contribute to the total dry-matter production of the plant.

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Importance of Taxonomy in Biological Investigations

Often in biological investigations no attempt is made to define with precision the species upon which the investigation was carried out. Terms without specific connotation, such as 'frog' or 'monkey', are used. This lack of precision may mean that data are lacking which may afterwards prove to be of significance in relation to the purpose of the paper.

Another reason why precision in identification of species is desirable is that there is probably much to be gained from a greater integration of knowledge obtained by investigation of living forms with our knowledge of taxonomy, gleaned in large measure from the fossil record of extinct forms. This will only be possible if all types of biological investigators pay attention to the taxonomical classification of the subjects of their study. Such a correlation of knowledge should reflect to the benefit not only of taxonomy but also of biological science in general. So far as comparative anatomy is concerned, a closer consideration of taxonomy and modern concepts of the relation of groups in the evolutionary process should prevent the hasty drawing of false homologies between structures which are only superficially similar.

The following example indicates the mutual benefit that may derive to descriptive anatomy and taxonomy by attempting correlation between them. Among selachian fishes (that is, members of the sub-class Selachii of the class Elasmobranchii[1]) fusion of the two lateral telencephalic lobes of the forebrain occurs, except in *Scymnorhinus*, in which the lateral telencephalic lobes remain unfused. The primary site of attachment of the nervus terminalis is on each side lateral to the lamina terminalis, but this is only clearly seen in the mature brain in *Scymnorhinus*. In other forms the proximal part of the nerve is incorporated in the brain by the fusing telencephalic lobes, the nerve being carried either dorsally or ventrally in this process, so that its definitive site of superficial attachment is either dorsal or ventral[2]. The nervus terminalis in selachians[2] is thus attached in some forms dorsally to the forebrain and in others ventrally. If the various forms are viewed merely as a number of selachians, this detail of descriptive anatomy, concerning as it does a minute nerve of uncertain function, can scarcely seem to be of much interest, especially when it is remembered that the definitive site of attachment of this minute nerve is secondary, being dictated probably by largely mechanical factors during fusion of the telencephalic lobes. However, if the forms in which the site of attachment of the nervus terminalis has been recorded are reviewed from a taxonomical point of view, it is found that the attachment is dorsal in the skates and rays (sub-order Hypotremata, order Euselachii); and, among the sharks of the order Euselachii, which are classified as the sub-order Pleurotremata, it is dorsal in the superfamily Squaloidea (except in *Scymnorhinus*, see above, in which it is rostral). Among euselachian sharks, the attachment is ventral in the superfamily Scylloidea, and a ventral attachment is found in the protoselachian Port Jackson shark (*Heterodontus*). These results all correlate well with current taxonomical classification. The only inconsistency appears in the superfamily Notidanoidea of euselachian sharks, since in *Hexanchus* and *Heptranchias* the attachment is dorsal[4], whereas in *Chlamydoselachus* it is ventral[5]. The site of superficial attachment of the nervus terminalis may not be of particular taxonomical significance; but it serves to illustrate

how accumulated observations might be used to corroborate or to modify taxonomical classification, and how even apparently trivial descriptive details may be seen to have meaning when viewed in the light of taxonomy.

A suggestion for more attention by biological investigators to taxonomy must, unfortunately, be accompanied by a plea for the devotion of more precision and care to the use of correct generic[6] and specific[7] names.

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Information Gain in Tasks involving Different Stimulus-Response Relationships

IN an attempt to clarify issues raised by changes associated with age in the ability of human subjects to perform perceptual-motor tasks, the rates of information transmission of younger and older subjects in performing discrete, choice reaction time tasks involving two different stimulus-response relationships were calculated. The tasks involved moving a stylus as quickly as possible from a central point to one of a number of targets arranged in a semi-circle in response to the appearance of one of a number of signal lights arranged in a similar semi-circle. The first (direct) stimulus-response relationship required subjects to aim at targets corresponding directly in position to signals which appeared. In the second, indirect version of the task, the correct target was the 'mirror image' of that directly indicated by the signal.

It was found that: (1) in all cases, the mean reaction time of subjects was proportional to the amount of information conveyed by the signal; (2) rate of information transmission was lower in both younger and older subjects when the stimulus-response relationship was indirect; (3) in both stimulus-response relationships, the rate of information transmission of older subjects was lower than that of younger subjects. The first of these findings is in line with those of Hick[1], Hyman[2] and others, and the second confirms work by Crossman[3] and others. In these previous studies, however, age was not treated as an experimental variable. The third finding supports a hypothesis of Welford[4] in explanation of age changes in perceptual-motor performance, that the ability to process information centrally deteriorates with age.

The calculated rates of information transmission were derived from the a constants in the functions which were found to fit the mean reaction time data in all cases. These functions all took the general form:

$$R.T. = a \log_2 \frac{1}{p} + b \qquad \text{(I)}$$

where $R.T.$ is the mean reaction time (sec.) to signals the probability of occurrence of which is p. Calculated rates of information transmission were given by the formula:

$$R = \frac{1}{a} \qquad \text{(II)}$$

where R is mean rate of information transmission (bits/sec.).

The specific forms these regressions took were as follows:

Direct S–R relationship	Younger *Ss* $R.T. = 0{\cdot}073 \log_2 \frac{1}{p} + 0{\cdot}288$	(III)
	Older *Ss* $R.T. = 0{\cdot}094 \log_2 \frac{1}{p} + 0{\cdot}307$	(IV)
Indirect S–R relationship	Younger *Ss* $R.T. = 0{\cdot}127 \log_2 \frac{1}{p} + 0{\cdot}296$	(V)
	Older *Ss* $R.T. = 0{\cdot}171 \log_2 \frac{1}{p} + 0{\cdot}301$	(VI)

These results lend themselves to interpretation in an interesting manner. The calculation of rates of information transmission on the basis of the a constants of equations (III) to (VI) suggests that in the indirect version of the task lower rates applied than in the direct version. This implies that the information-processing capacity of the human operator varies from task to task, which, on purely *a priori* grounds, is a somewhat unsatisfactory view. This difficulty may be avoided if it is recognized that equations (V) and (VI) may be re-written in such a manner as to retain the values of the a constants present in equations (III) and (IV), respectively. Equation (V), re-written in this manner, would be:

$$R.T. = 0{\cdot}073 \left\{\frac{0{\cdot}127}{0{\cdot}073}\left(\log_2 \frac{1}{p}\right)\right\} + 0{\cdot}296 \qquad \text{(VII)}$$

and equation (VI), re-written, would be:

$$R.T. = 0{\cdot}094 \left\{\frac{0{\cdot}171}{0{\cdot}094}\left(\log_2 \frac{1}{p}\right)\right\} + 0{\cdot}301 \qquad \text{(VIII)}$$

The implication of these re-written equations is that it is not the rate of information transmission which varies from task to task but the amount of information conveyed by signals. In the indirect version of the task, this is increased by the factor by which the expression $\log_2 1/p$ is multiplied. Further, the approximate equality of these factors in equations (VII) and (VIII), 1·74 and 1·80, respectively, suggests that to both younger and older subjects the amount of information conveyed by signals is increased to the same extent.

While involving a modification of the conventional use of information theory in the interpretation of psychological data, the interpretation proposed above appears to represent a useful descriptive foundation upon which the interpretation of data obtained under different conditions of stimulus-response coding may be based. Full details of the experiment and a fuller discussion of the interpretation proposed here will appear elsewhere.

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Department of Psychology,
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After-Effect of Movement produced by a Rotating Spiral

Following visual stimulation by a rotating spiral, a negative after-effect of movement is observed. A preliminary report on what variables are relevant has been made by Holland[1]. Eysenck, Holland and Trouton[2] have since claimed that individual differences in length of after-effect conform to predictions from Eysenck's theory. In view of these claims and of the fact that others[3,4] are using this phenomenon in a clinical diagnostic context, it is perhaps important to offer this progress report of further experiments on the extent of normal variation and the factors influencing it.

The number of subjects participating in these experiments was eighty. The spiral was of the same pattern as that used by Eysenck, Holland and Trouton[2]. The principal findings may be summarized as follows:

The variables influencing the duration of the after-effect (other than individual differences).

(1) Duration of after-effect is very resistant to changes in illumination over a wide range (approximately 120–20 ft. candles on the surface of the spiral with the subject seated about 5 ft. away) ($N = 30$). Between 27 and 0·4 ft. candles there is a slight drop in mean duration from 10 sec. to 8 sec. ($P > 0{\cdot}05$), but it is substantially unaltered until the spiral is so dim that fusion occurs during rotation, and it is then destroyed ($N = 10$).

(2) Continuous trials cause a decrement in the duration of after-effect. There is a difference between the same condition repeated at the beginning and end of a series of thirteen intervening measurements ($P > 0{\cdot}01$). The same condition, repeated at random among the thirteen, had a mean value midway between the two extremes ($N = 23$).

These findings confirm and extend previous work[1,2], whereas the following observations are discrepant.

(3) Length of stimulation results in increase in the duration of effect over the whole range tried (5 sec.–10 min.). Subjects with persistent after-effects tend to show greater proportional as well as actual gain; for example, between 2½ and 5, and 5 and 10 min. stimulation there is a gain of more than ½, compared with 1/3 and 1/5 respectively in those with very short after-effects ($N = 45$).

(4) The after-effect is shorter using a spiral 3 in. in diameter than one 6 in. in diameter ($P > 0{\cdot}05$, $N = 18$). It is also shorter than when using a disk 12 in. in diameter but not significantly so ($N = 21$).

(5) Of twenty-five subjects only nine were able to view the spiral monocularly and observe the after-effect with the unstimulated eye. Five did so in one direction only, and the other eleven did not find any transfer of the effect. Duration of after-effect tends to be less, but not in all subjects.

(6) Twenty-three out of the twenty-five subjects were able to observe the after-effect on a relatively unstructured surface—a black card. Duration of after-effect differs for individuals from that under the usual conditions of observation, but there is no overall diminution.

Further experiments showed:

(7) That the wave-length of light in which the spiral is viewed has no effect ($N = 11$).

(8) There is no difference produced by contracting and expanding spirals ($N = 20$).

(9) Rotation at 16 r.p.m. produces a significant decrease compared with 45 and 78 r.p.m., between which there is no difference ($P > 0{\cdot}001$, $N = 22$).

(10) Fixation of a point on the periphery of a spiral 12 in. in diameter produces marked decrement compared with fixation of the centre ($P > 0{\cdot}001$) and similarly for fixation of a point 10 in. away from the centre of a spiral 3 in. in diameter ($P > 0{\cdot}01$, $N = 22$).

(11) Monocular viewing slightly decreases the after-effect. Values for each eye separately are lower than for both together ($P > 0{\cdot}1$, $N = 18$).

(12) Striking subjective colours are reported by some subjects, especially with prolonged stimulation, and there is a considerable degree of consistency in the quality and location of the colours seen under particular conditions.

The effect of individual differences. Contrary to previous assertions[2], no significant differences at any of eight different periods of stimulation were found between the 12 most extroverted and 12 most introverted subjects, selected by their extroversion scores on the Maudsley Personality Inventory[6] from a group of 76.

Diagnostic value. Previous studies, using as criterion the presence or absence of after-effect, report varying percentages of organics who perceive the after-effect; however, none of the studies[4,5] using normals as controls reports complete failure to see the effect by any of the normal group. Thus there is recognized to be overlap between organics and normals in their ability to see the effect, but not in failure to see it. Of our eighty subjects, however, four saw no after-effect, even after prolonged stimulation, and it therefore seems unwise to assume that absence of the effect is evidence of brain-damage.

Holland and Beech[5] have suggested that the duration of after-effect may discriminate between normal subjects and those with brain damage. Apart from the four mentioned above, there were nine subjects in whom duration of after-effect was below that reported by Holland and Beech as the minimum for their normal group, and which, taken as a cut-off point, identifies eight out of their 21 organics without misclassification. 16 per cent of the 'normal' subjects in this study would, on this basis, be diagnosed as having brain damage.

In view of various discrepancies between these results and those previously reported, further work would seem necessary before anything can be asserted about the nature of the individual differences related to differences in length of after-effect, or about the diagnostic value of this phenomenon.

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FORTHCOMING EVENTS

Tuesday, December 30—Friday, January 2

GEOGRAPHICAL ASSOCIATION (at the London School of Economics, Houghton Street, London, W.C.2)—Annual Conference.

Wednesday, December 31

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 3 p.m.—Dr. E. R. Laithwaite: "Invention and New Machines". (Christmas Holiday Lecture. To be repeated on January 1 at 3 p.m.)

Thursday, January 1

POLAROGRAPHIC SOCIETY (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Some Problems Encountered in the Application of the Polarograph to the Analysis of Copper-Base Alloys" introduced by Mr. G. Sale.

Thursday, January 1—Friday, January 2

ROYAL PHOTOGRAPHIC SOCIETY (in the Department of Photography, The Polytechnic, 309 Regent Street, London, W.1), at 2.30 p.m. daily —Lectures on "Picture Making in Photography". (Annual lectures for a Juvenile audience of between 12 and 17 years.)

Friday, January 2

PLASTICS INSTITUTE (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 2.30 p.m.—Mr. E. Rushton: "Plastics and Electricity" (Young People's Lecture).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHAIR OF PHYSICAL CHEMISTRY, CHAIR OF MATHEMATICS, and CHAIR OF PHYSICS in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 31).

LECTURER IN CHEMISTRY, for classes to G.C.E. Advanced level—The Principal, Watford Technical College, Hempstead Road, Watford, Herts (December 31).

TECHNICIAN (preferably with the ability to handle complex physical apparatus) IN THE RADIOISOTOPES LABORATORY, Pollards Wood Research Station, Chalfont St. Giles, Bucks, to assist with investigations on the biosynthesis of proteins and nucleic acids—The Secretary, Chester Beatty Research Institute, Fulham Road, London, S.W.3, quoting "Isotopes" (December 31).

LABORATORY TECHNICIANS at Brunel College of Technology, for (*a*) maintenance of physical instruments in the Chemistry Department, and (*b*) maintenance of laboratories and equipment in the Biology Division—The Registrar, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3, quoting Y.801 N (January 3).

GRADUATE ASSISTANT IN THE UNIT OF BIOMETRY, for duties which include teaching and consultation on the mathematical and statistical treatment of biological problems, and also research on biometric theory—The Reader, Unit of Biometry, The University, 7 Keble Road, Oxford (January 10).

LECTURER IN PHYSIOLOGY—The Secretary, Institute of Basic Medical Sciences, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (January 10).

PLANT BREEDER (with an honours degree in science or agricultural science majoring in plant breeding or genetics and research experience in these fields, with plants of tropical or sub-tropical origin) at the Plant and Soils Laboratory, Commonwealth Scientific and Industrial Research Organization, Brisbane, Queensland, Australia, to take part in a plant breeding programme aimed at developing adapted strains of pasture legumes and grasses and pulse crops for sub-tropical Queensland—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 146/109 (January 10).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, for duties which will include teaching and research in microwave engineering—The Registrar, The University, Leeds 2 (January 12).

DEMONSTRATOR (male, with a good honours degree in chemistry) IN CHEMISTRY, and a DEMONSTRATOR (male, with a good honours degree in physics) IN PHYSICS OR BALLISTICS at the Royal Military College of Science, Shrivenham, Berks—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.465/8A (January 16).

TECHNICIAN (with workshop and preferably previous hospital experience) IN THE PHYSICS DEPARTMENT—The Administrative Officer, Marie Curie Hospital, 66 Fitzjohns Avenue, London, N.W.3 (January 16).

CHAIR OF GEOLOGY—The Secretary, The University, Exeter (January 17).

LECTURER IN ANIMAL MANAGEMENT, and a LECTURER IN ANIMAL GENETICS at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 19).

SENIOR LECTURER/LECTURER IN ORGANIC CHEMISTRY at the University of New South Wales, Australia—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (Australia, January 22).

REGIUS CHAIR OF ASTRONOMY in the University of Glasgow—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (January 26).

LECTURER IN BIOCHEMISTRY—The Secretary of University Court, The University, Glasgow (January 31).

CHAIR OF ENGINEERING in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 10).

JUNIOR MYCOLOGIST (preferably with a good honours degree in botany, with mycology as a special subject, and a knowledge of Latin and other languages) at the Commonwealth Mycological Institute, Kew—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (March 15).

ASSISTANT RESEARCH OFFICER (aged 22–28, with a degree in agriculture or horticulture, and preferably a knowledge of statistical techniques as applied to field experimentation), for work on rubber, abaca, oil palms and other crops in North Borneo—The Personnel Officer, Colonial Development Corporation, 33 Hill Street, London, W.1, quoting Serial 353.

ENTOMOLOGIST (with a natural science degree from a British university, and preferably a knowledge of tsetse, particularly *Glossina morsitans*) IN THE VETERINARY DEPARTMENT, Northern Region of Nigeria, for duties involving tsetse surveys, identification of species, field observation of seasonal distribution and habits, and control of species—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.67/408/015.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER at the National Physical Laboratory, D.S.I.R., Teddington, Middlesex, to work on application of optical instrumentation in chemical and mechanical engineering industries—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.31/8A.

FELLOW IN THE DEPARTMENT OF CHEMISTRY, for fundamental research on electron resonance spectroscopy—The Registrar, The University, Birmingham 15.

PRINCIPAL, and a LECTURER IN PHYSICS AND MATHEMATICS at Bulawayo Technical College—The Secretary (R), Federation of Rhodesia and Nyasaland, Rhodesia House, 429 Strand, London, W.C.2.

PROFESSOR (male or female, preferably with Ph.D. degree or equivalent) OF PHYSICS—Mrs. L. L. Rappaport, Chairman, Department of Physics, Sweet Briar College, Sweet Briar, Virginia, U.S.A.

PROFESSOR (with a higher degree in civil engineering with hydraulics as the main subject, specialized knowledge of soil mechanics, water power engineering and hydraulics as applied to the design and construction of dams, and both university teaching and practical experience of dam projects) OF HYDRAULICS, DAM CONSTRUCTION AND IRRIGATION at the Poona Engineering College, India—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting E9/UNE/351/IND.

RESEARCH ASSISTANT (B.Sc., H.N.C. or equivalent, and preferably experience of steroid chemistry) to work for a team investigating aspects of chemical endocrinology in relation to human biology and genetics—The Secretary, Institute of Child Health (University of London), Great Ormond Street, London, W.C.1.

RESEARCH ASSISTANT (graduate in mathematics or statistics and interested in electronic computation) to work on a research project—Head of the Department of Mathematics, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

SCIENTIFIC OFFICER (with a first- or upper second-class honours degree in physics or electrical engineering), to assist in the study of fundamental processes involved in the behaviour of spark gap devices; to evaluate and interpret effects produced by ionizing and quenching agents; to investigate phenomena connected with the behaviour of gases under conditions of high temperature and pressure—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. B/1921/34.

SENIOR PHYSICIST IN THE RADIOTHERAPY DEPARTMENT, Pembury Hospital—The Group Secretary, Tunbridge Wells Group Hospital Management Committee, Sherwood Park, Pembury Road, Tunbridge Wells.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

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Library Association. Reference and Special Libraries Section—Yorkshire Group. A Select List of Periodicals in Yorkshire Libraries. Pp. iii+23. (Bradford: Library Association, 1958. Obtainable from E. Wilkinson, Esq., Hon. Treasurer, Commercial Library, Hall Ings, Bradford 1.) 6*s*. [1410

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Institution of Electrical Engineers. List of Members. Part 2: Associates, Graduates and Students. Pp. 400+56A. Supplement to List of Members, Part 1: Corporate Members and Companions. Pp. 10. (London: Institution of Electrical Engineers, 1958.) [2010

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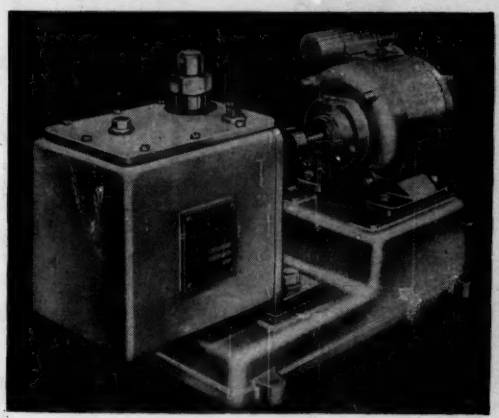

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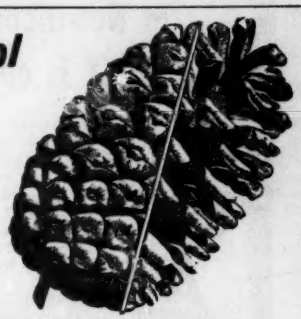

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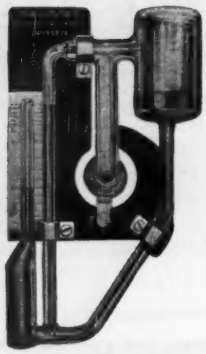

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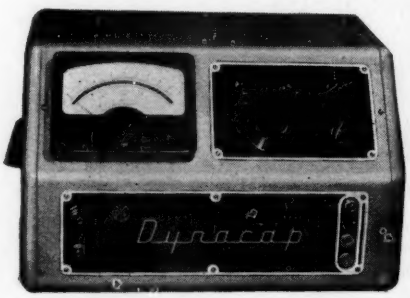

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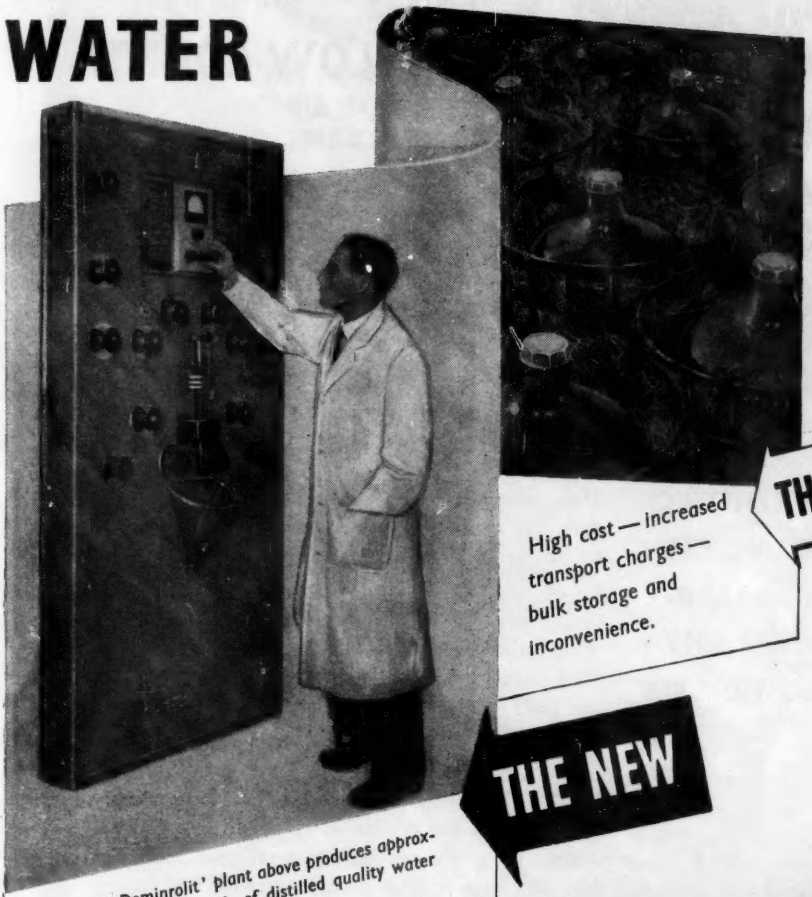

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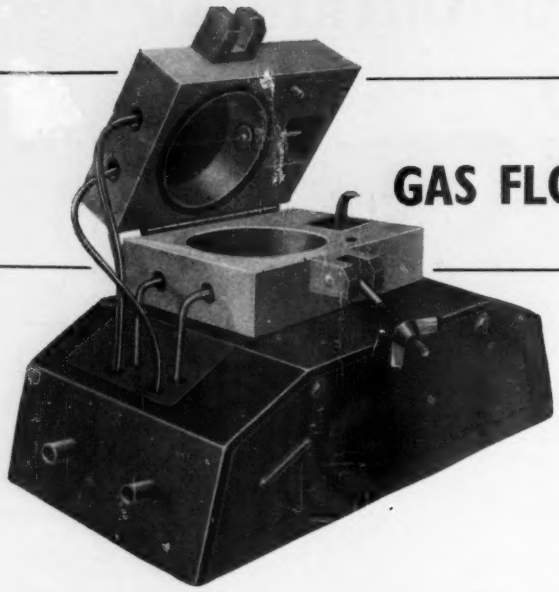

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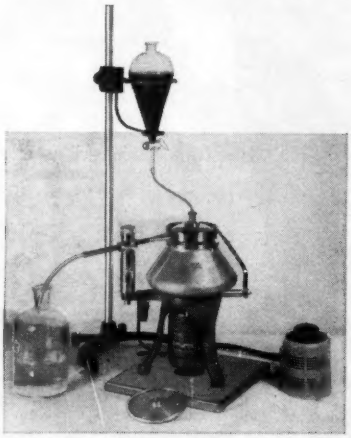

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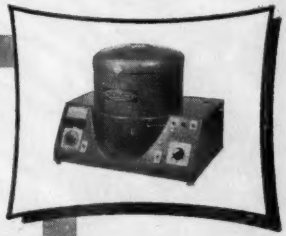

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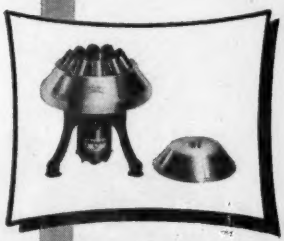

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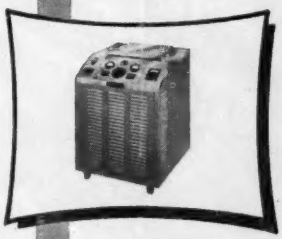

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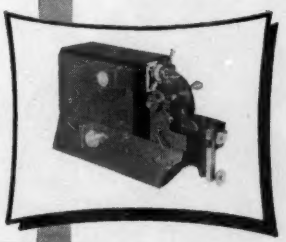

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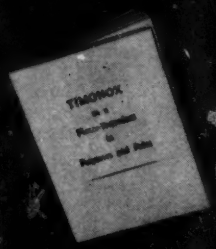

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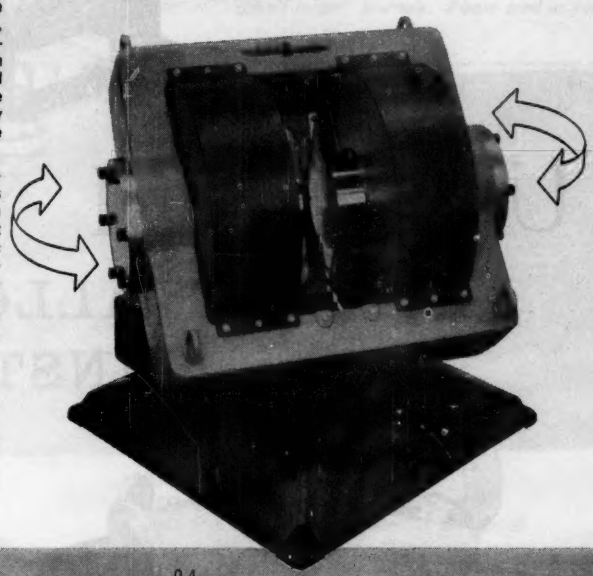

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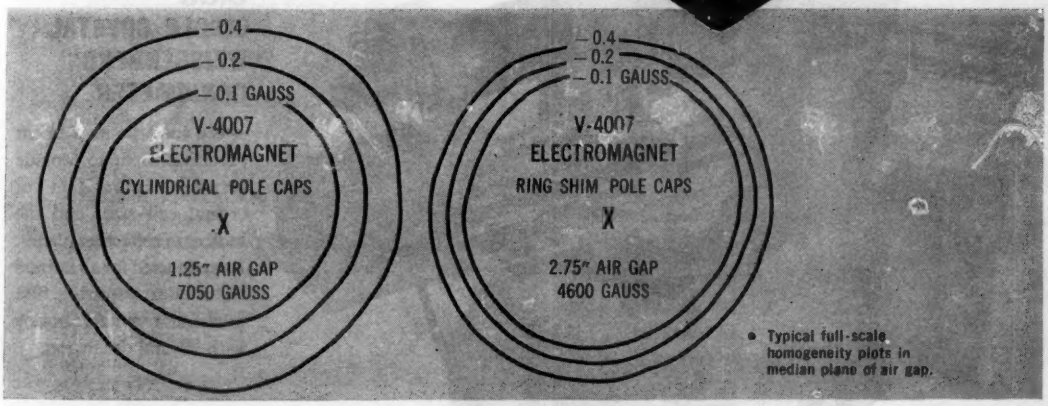

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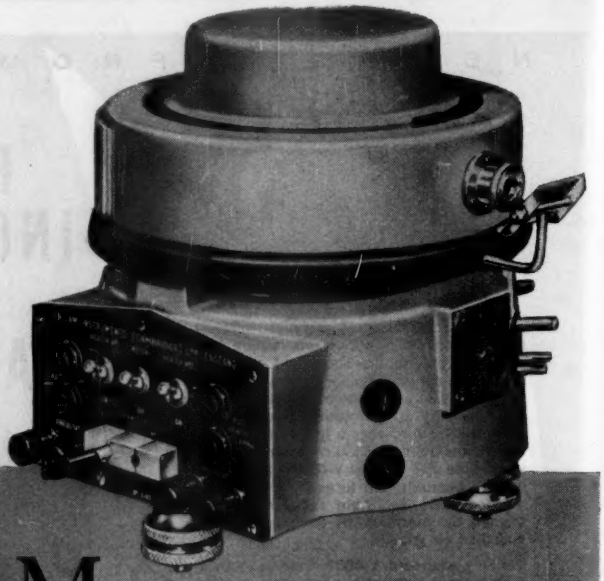

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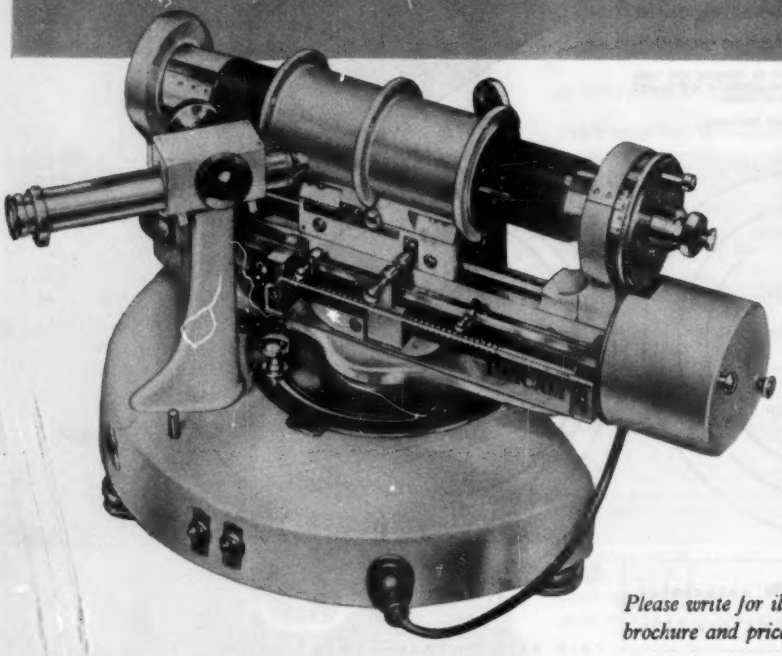

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